

United States Patent [19]

Oshima et al.

[11] Patent Number:

5,600,672

Feb. 4, 1997

OTHER PUBLICATIONS

Shanmugam, "Digital and Analog Communication Systems" 1979, p. 272.

Primary Examiner-Stephen Chin Assistant Examiner-Hai H. Phan

Attorney, Agent, or Firm-Wenderoth, Lind & Ponack

ABSTRACT

At the transmitter side, carrier waves are modulated according to an input signal for producing relevant signal points in a signal space diagram. The input signal is divided into, two, first and second, data streams. The signal points are divided into signal point groups to which data of the first data stream are assigned. Also, data of the second data stream are assigned to the signal points of each signal point group. A difference in the transmission error rate between first and second data streams is developed by shifting the signal points to other positions in the space diagram expressed at least in the polar coordinate system. At the receiver side, the first and/or second data streams can be reconstructed from a received signal. In TV broadcast service, a TV signal is divided by a transmitter into low and high frequency band components which are designated as first and second data streams respectively. Upon receiving the TV signal, a receiver can reproduce only the low frequency band component or both the low and high frequency band components, depending on its capability. Furthermore, a communication system based on an OFDM system is utilized for data transmission of a plurality of subchannels, wherein the subchannels are differentiated by changing the length of a guard time slot or a carrier wave interval of a symbol transmission time slot, or changing the transmission electric power of the carrier.

12 Claims, 178 Drawing Sheets

4,963 11/1	1992 Lawrence et al	
(HDTV) SIGNAL	VIDEO ENCODER INPUT SECTION 1ST DATA STREAM INPUT 7430 1ST VIDEO ENCODER ECC 2ND DATA STREAM INPUT 7440 2ND DATA STREAM INPUT 7440 2ND DATA STREAM INPUT 7440 PSK CONVERTER 7441	TRANSMITTED SIGNAL
HOTY (SOTY)	VIDEO DECODER OUTPUT SECTION 1ST DATA STREAM OUTPUT 758 DEMOQULATOR 1ST VIDEO DECODER ECC 1ST VIDEO DECODER 2ND DATA STREAM OUTPUT 758a PSK DOWN CONVERTER D2 2ND VIDEO DECODER ECC ECC ENCODER	RECEIVED
	759	

Date of Patent:

[54] COMMUNICATION SYSTEM

[75] Inventors: Mitsuaki Oshima, Kyoto; Seiji

Sakashita, Osaka, both of Japan

[73] Assignce: Matsushita Electric Industrial Co.,

Ltd., Osaka, Japan

[21] Appl. No.: 240,521

May 10, 1994 [22] Filed:

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 857,627, Mar. 25, 1992.

[30]	Foreign Application Priority Data				
Mar	27, 1991	(JP)	Jánan	3-62798	
	25, 1991	[37]	Innan	3-95813	
Mpt.	29, 1991	(JP)	Japan	3-155650	
	23, 1991	ijpi	Ianan	3-182236	
	17, 1992	(35)	Innan	4-60739	
	10, 1993	[אנן	Japan	5-132984	
	24, 1993	(15)	Ianan	5-261612	
Dec	27, 1993	(JP)	Ianan	5-349972	
	24, 1994	[JP]	Japan	6-79668	
[51]	Int. Cl.6			H04L 5/16; H04B 1/38	
	TIC CI	************		375/219; 375/270; 375/301;	
[52]	U.S. CI.	***********	**********	375/321	
[58]	Field of	Search		375/219, 259. 261, 262, 265, 270, 240, 321.	
		3/.)/ ZOU,	201, 202, 203, 270, 240, 321,	

References Cited [56]

U.S. PATENT DOCUMENTS

375/265

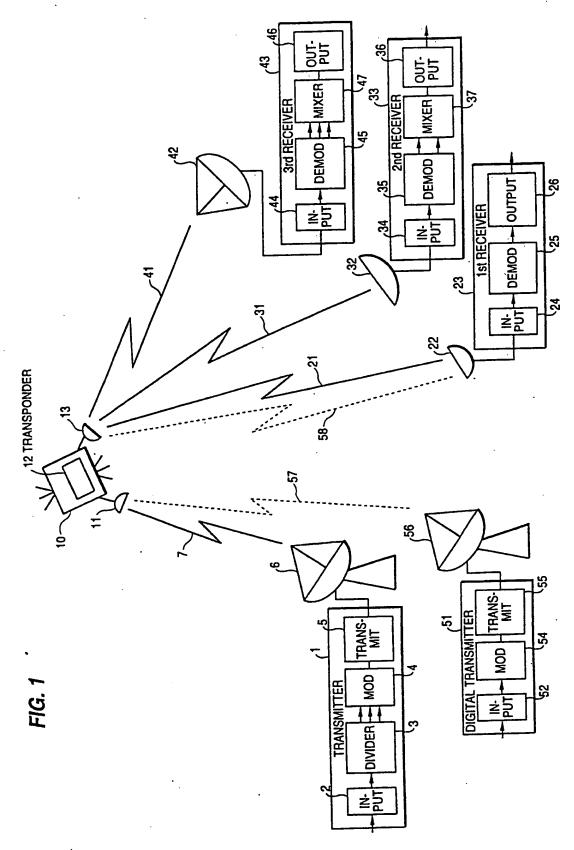
326, 341, 354; 348/725, 726, 723, 724

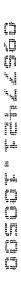
U.S. Patent

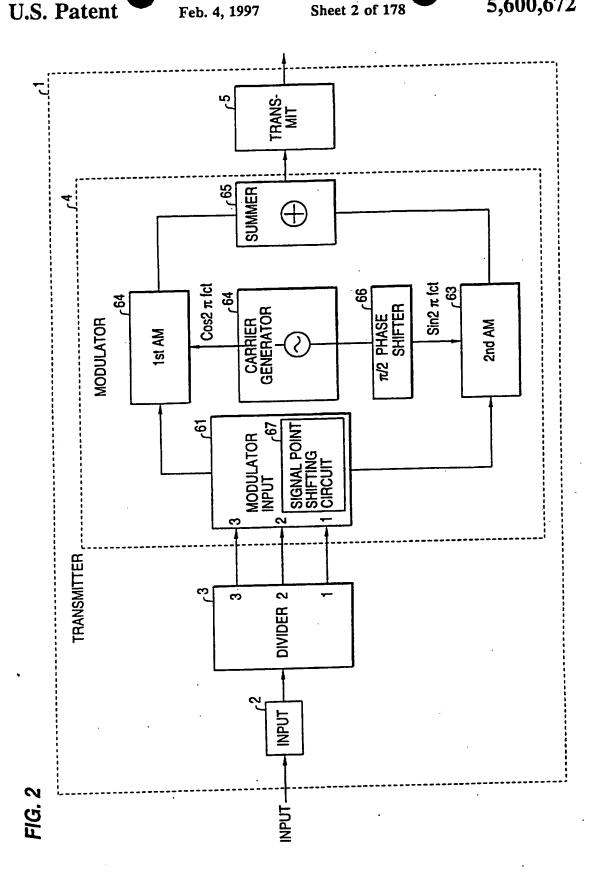
Feb. 4, 1997

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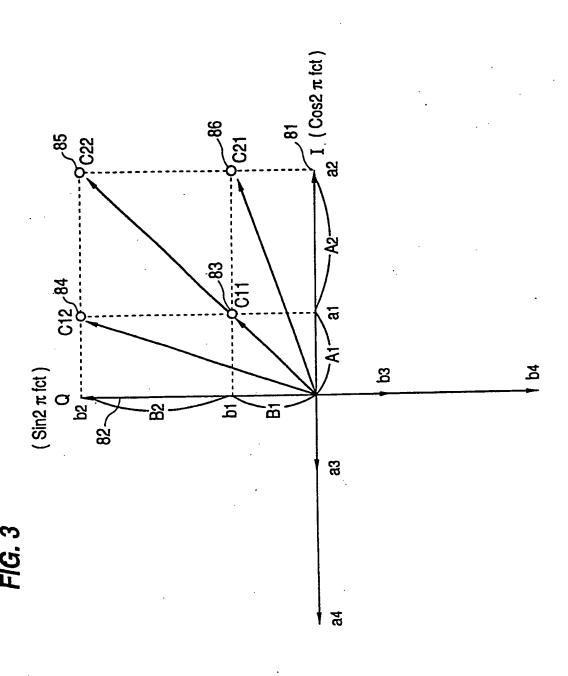
5,600,672

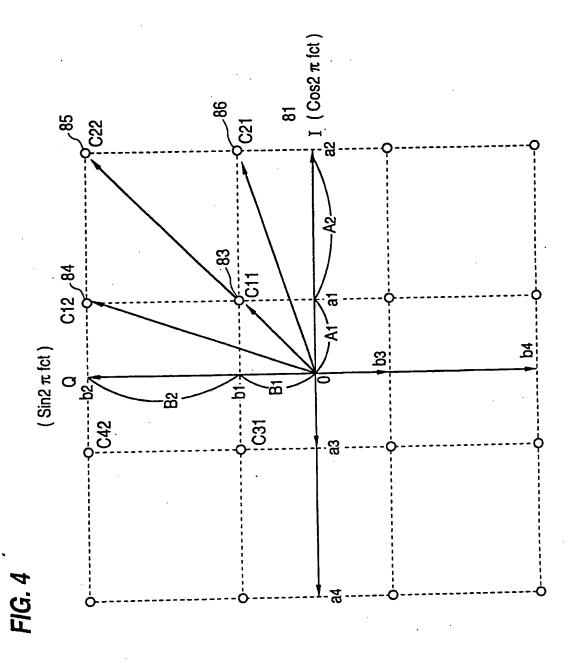












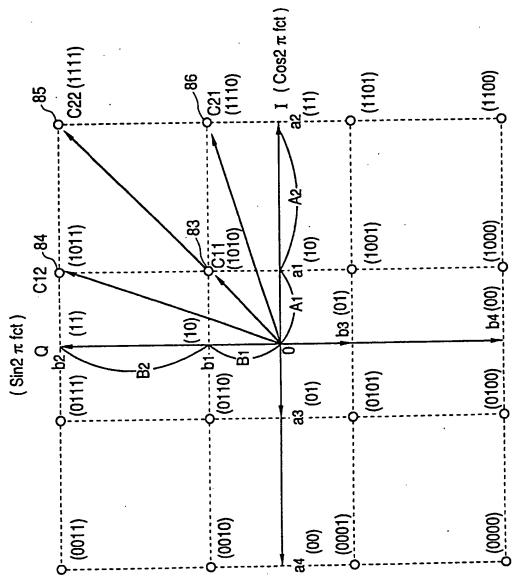
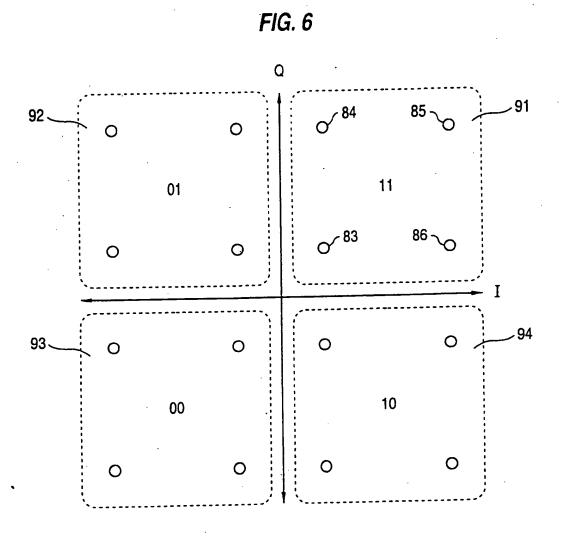
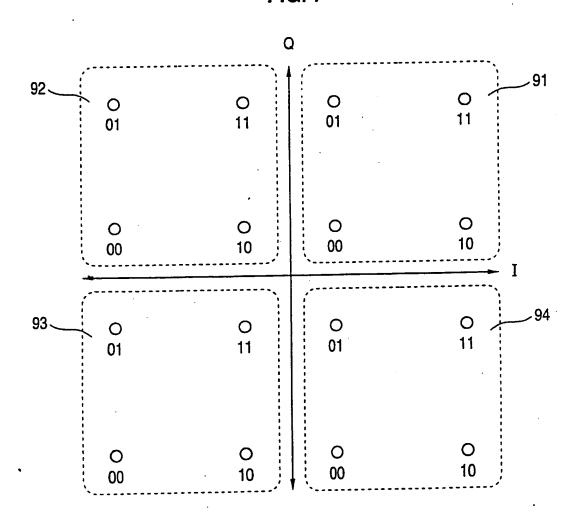


FIG. 5



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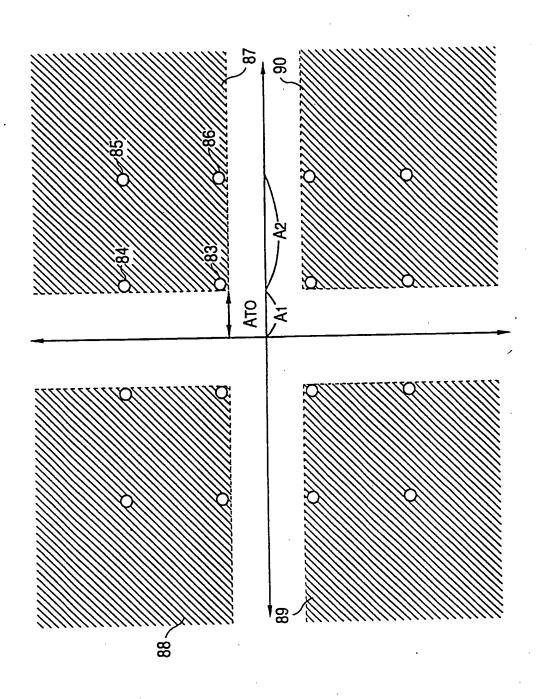
FIG. 7

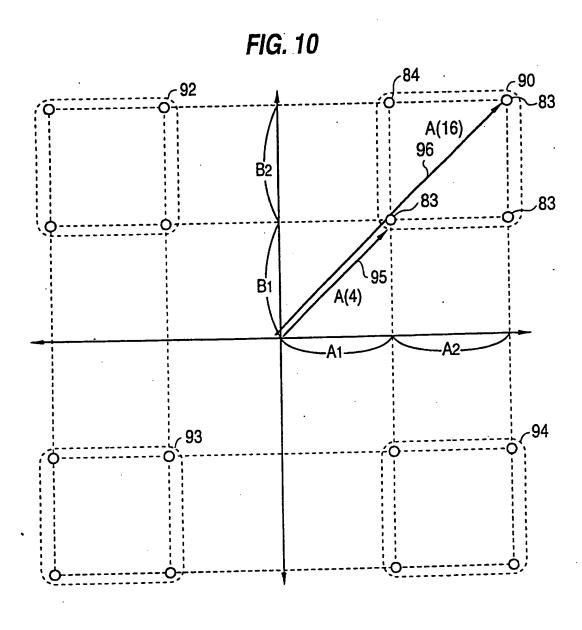


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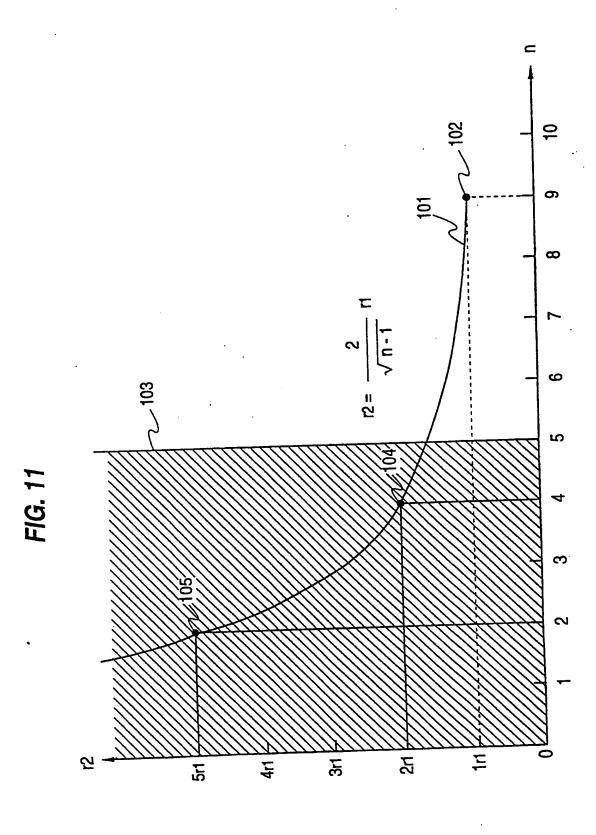
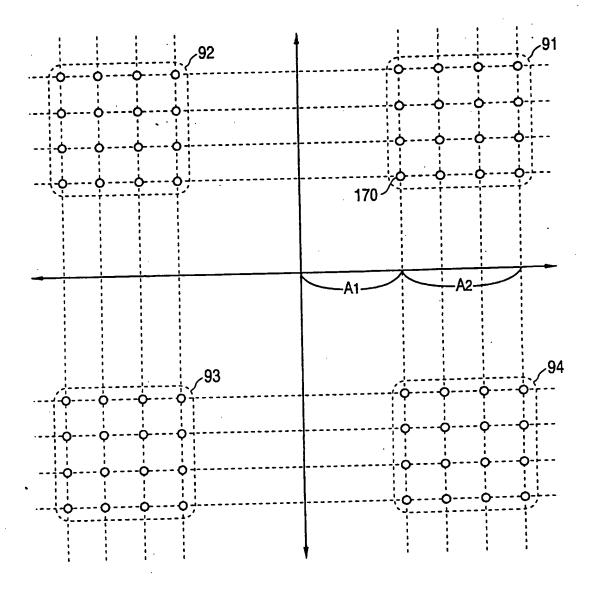
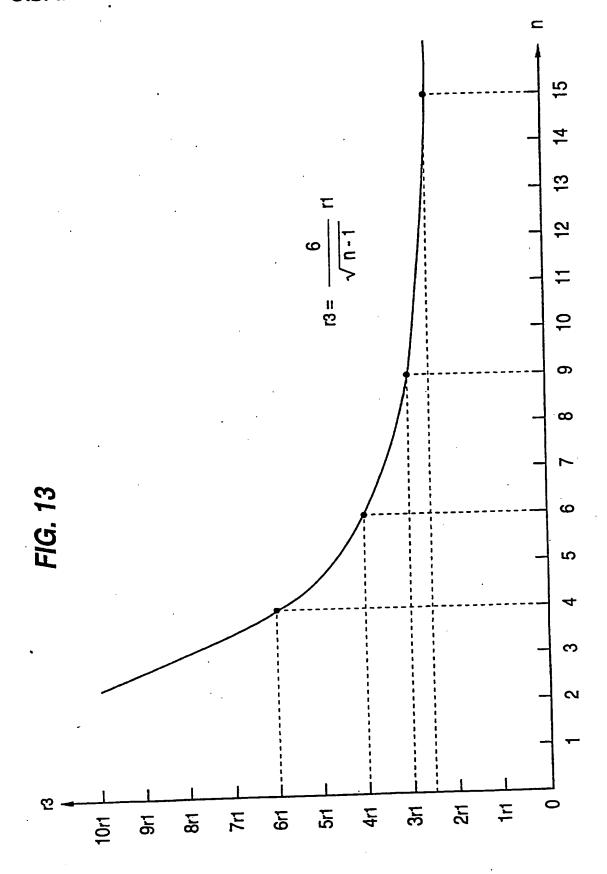
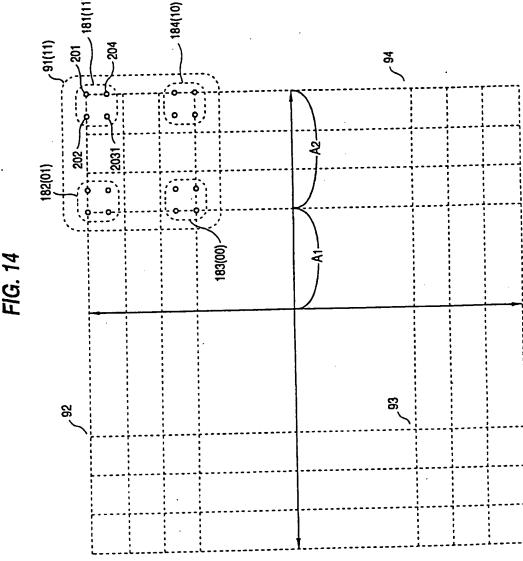


FIG. 12



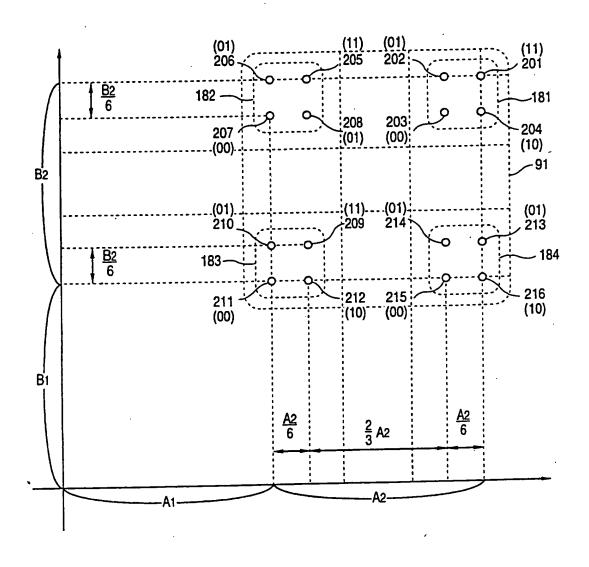


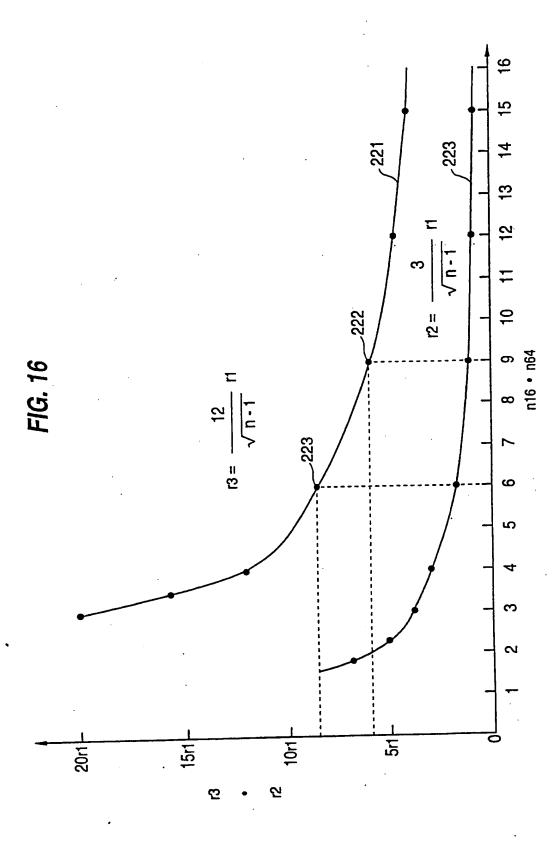




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FIG. 15





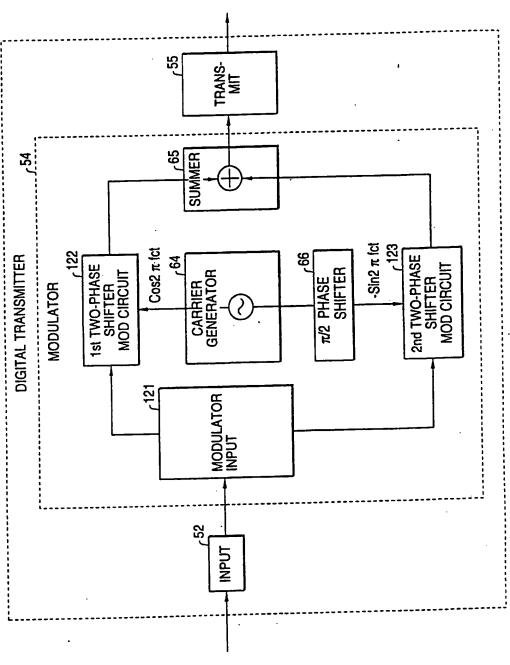
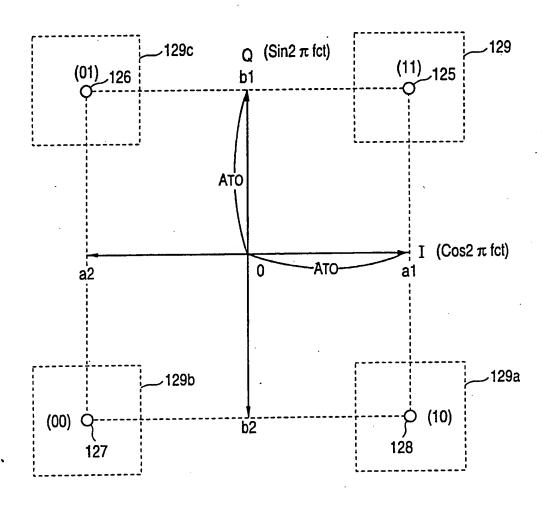
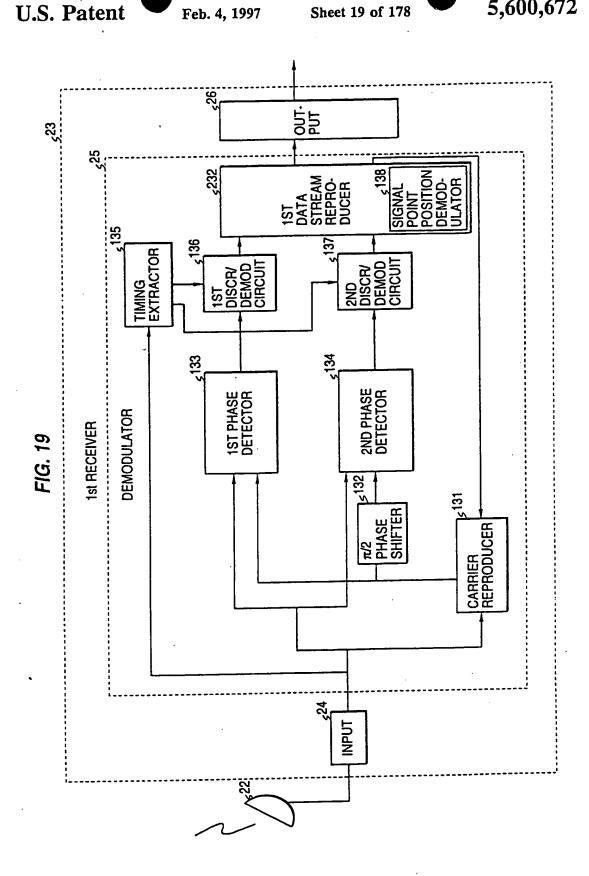


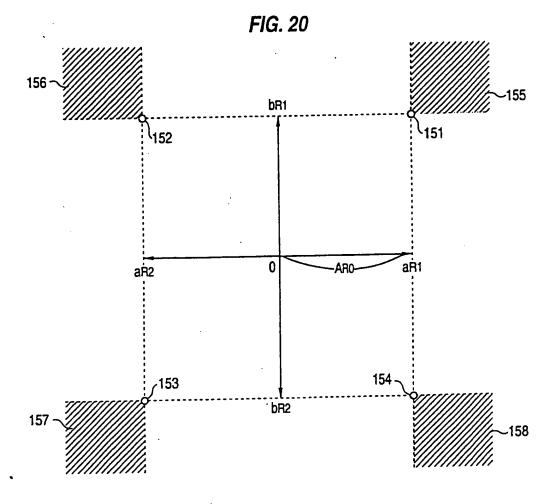
FIG. 17

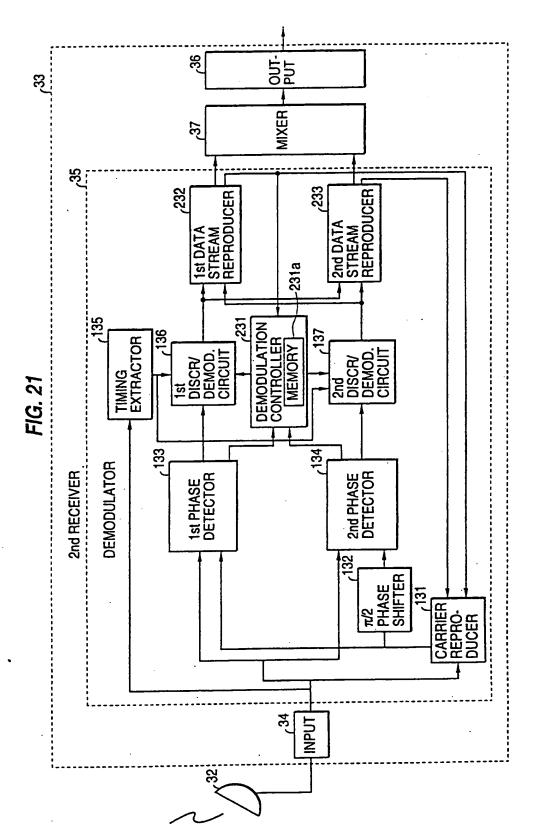
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FIG. 18



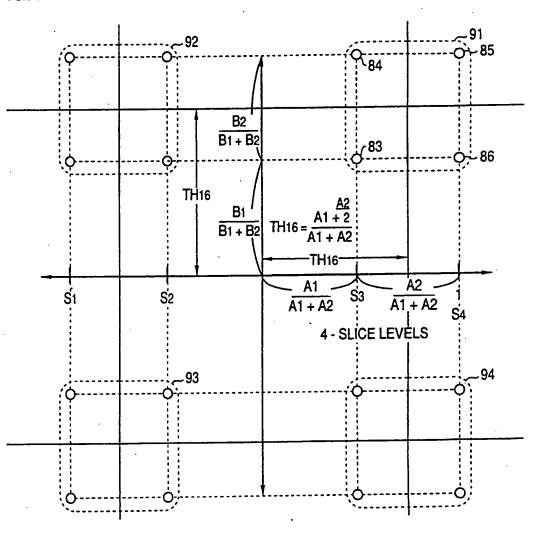






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FIG. 22



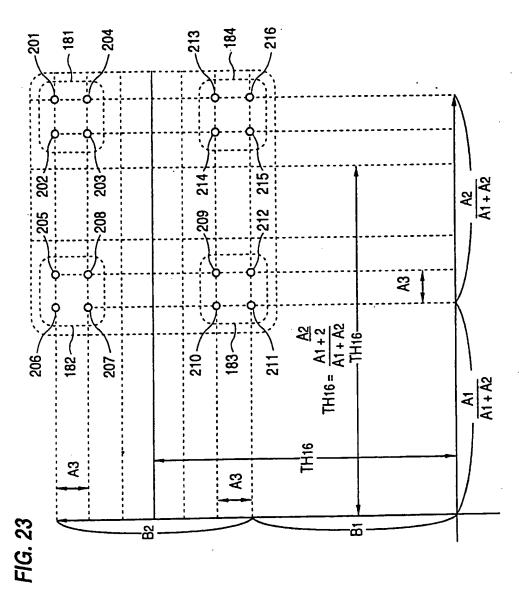


FIG. 24

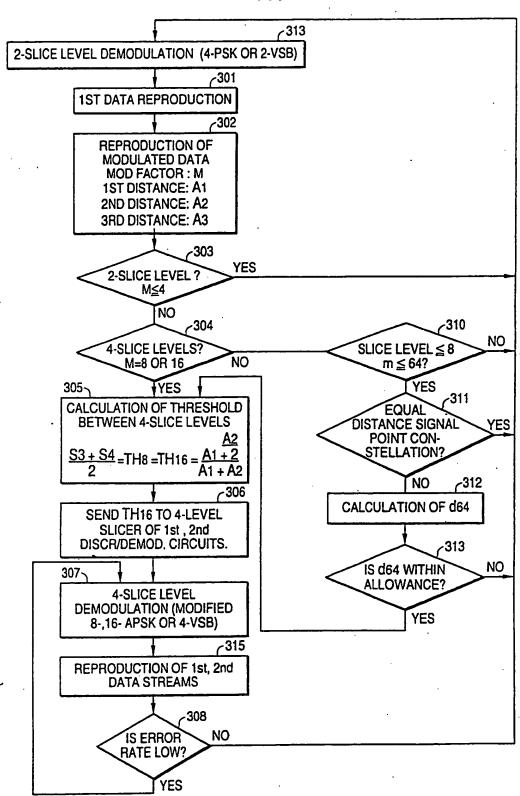


FIG. 25(a)

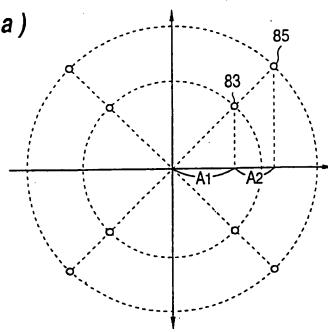
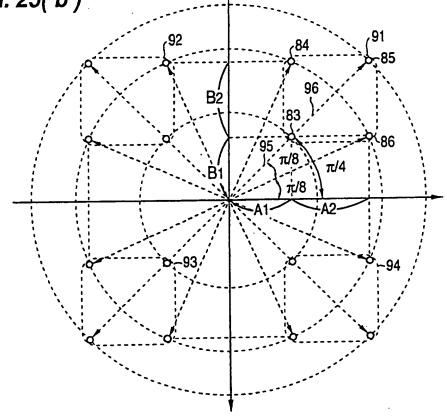
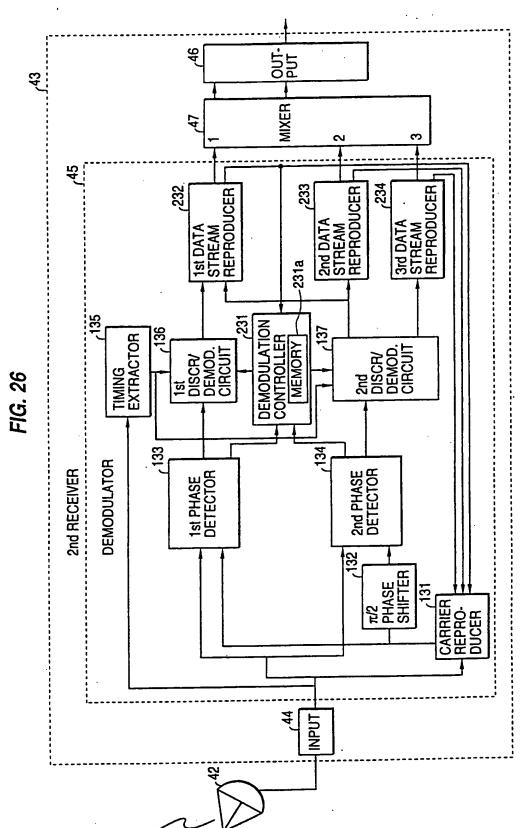


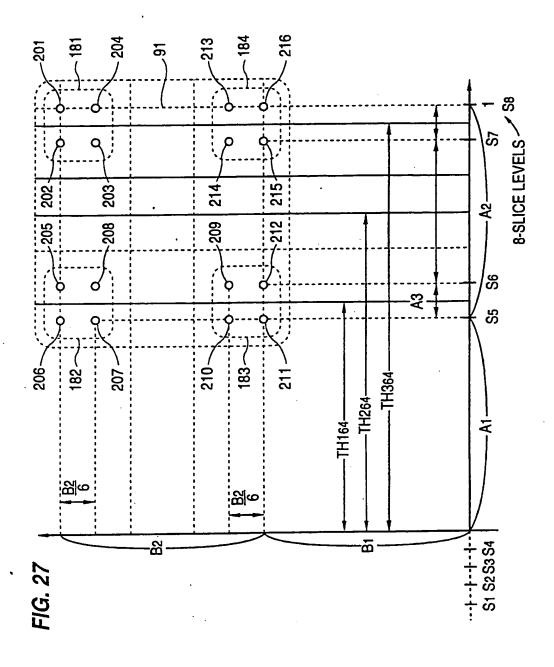
FIG. 25(b)



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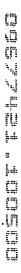
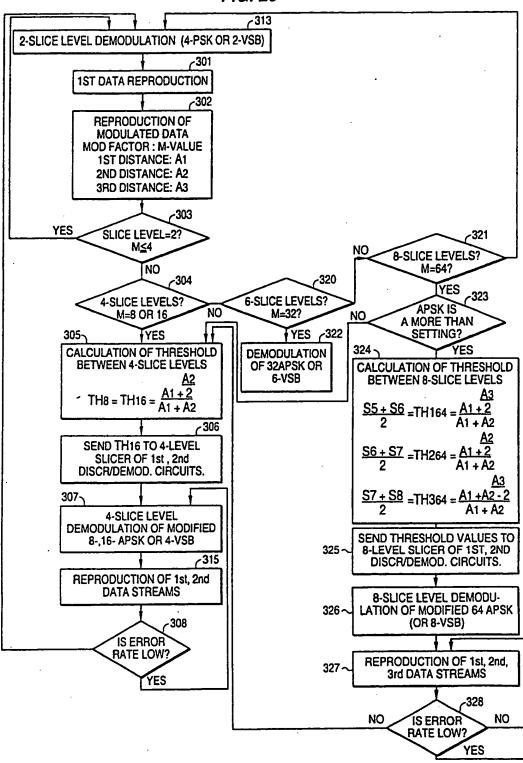
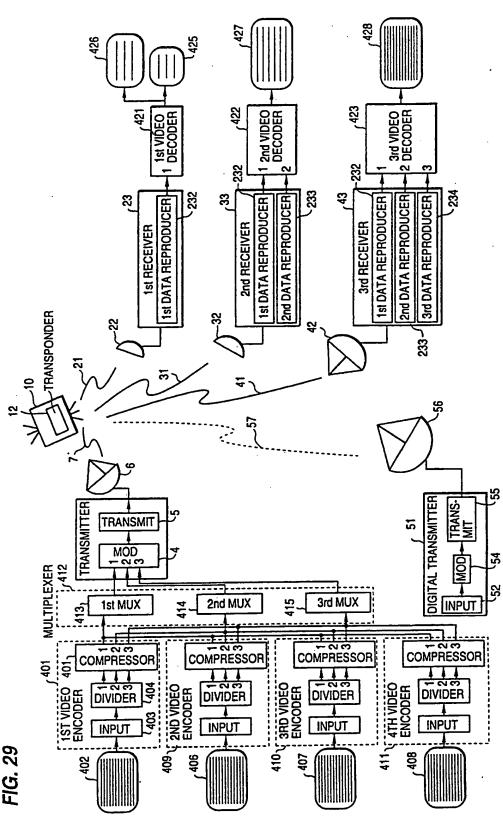
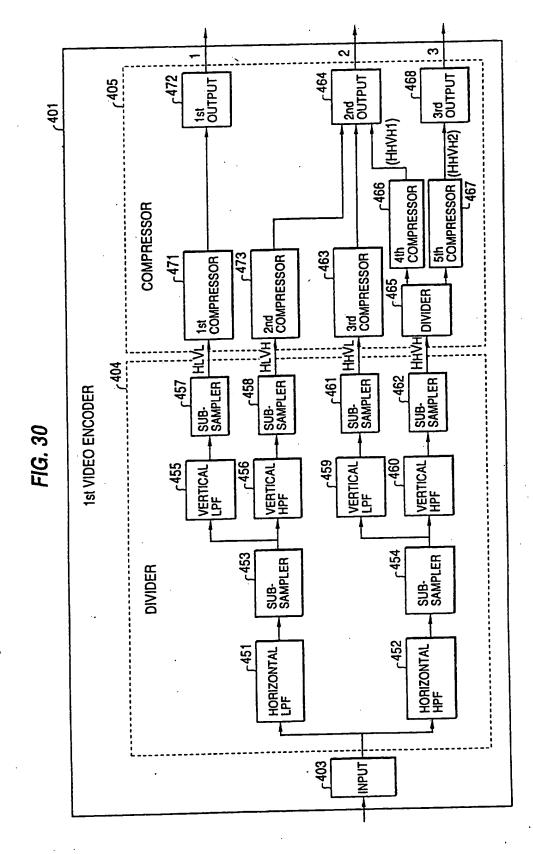


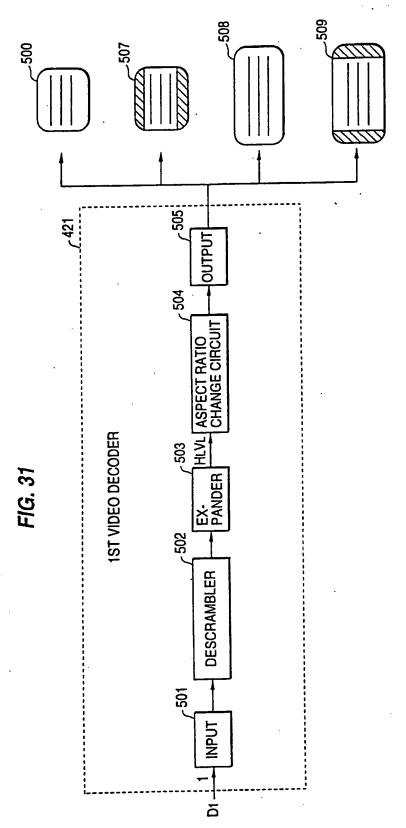
FIG. 28

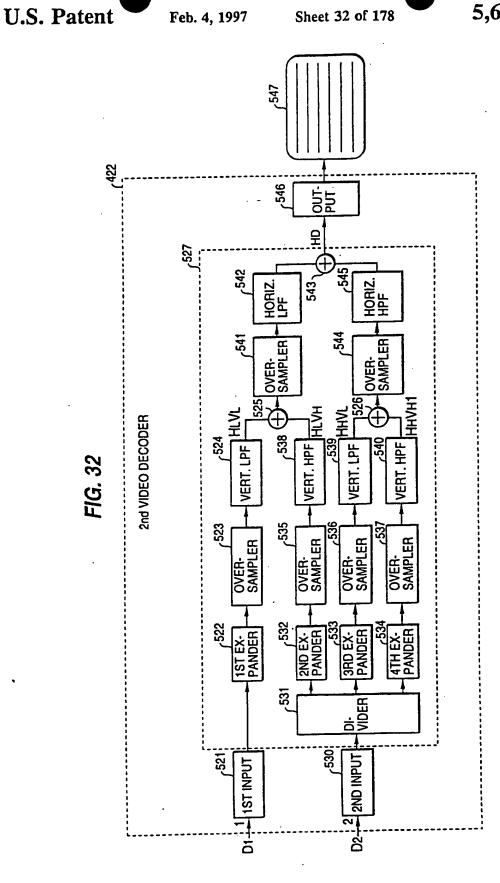


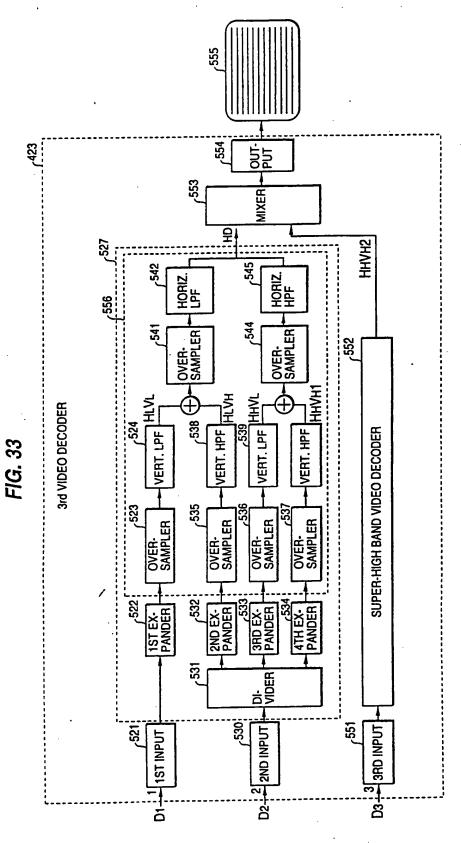


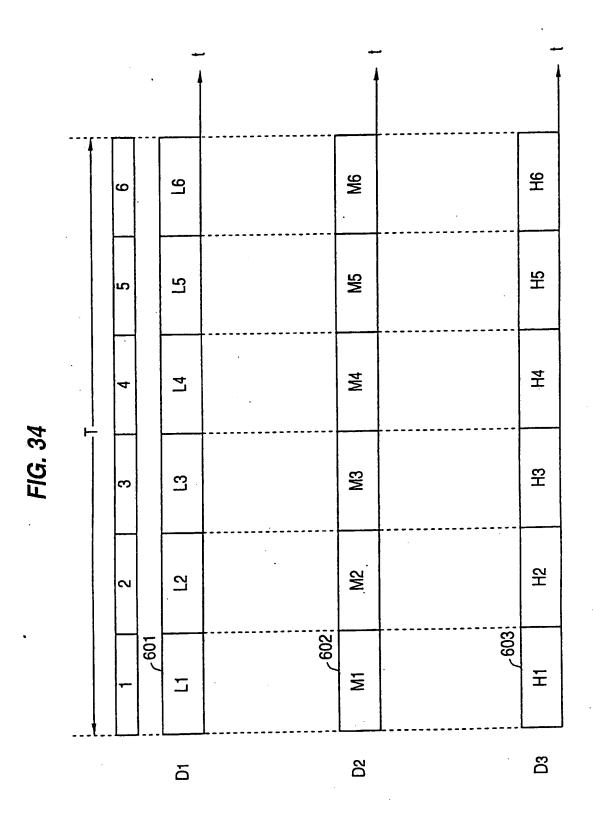


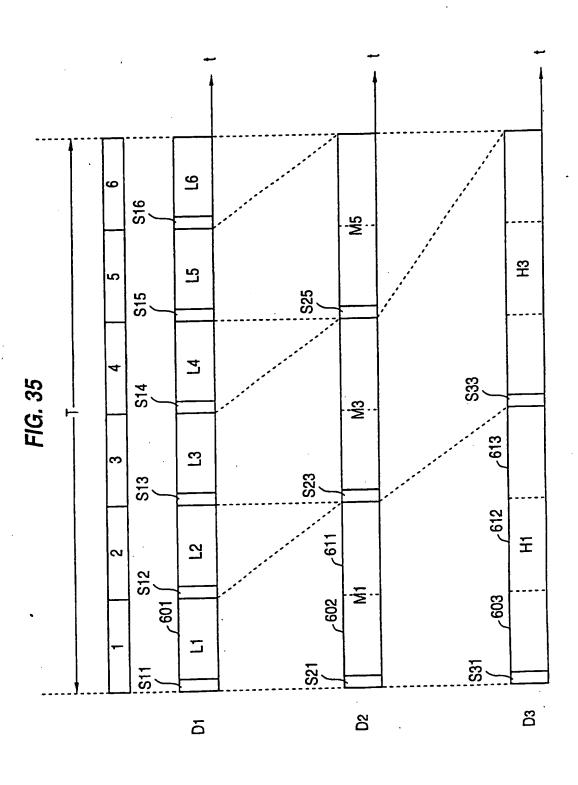




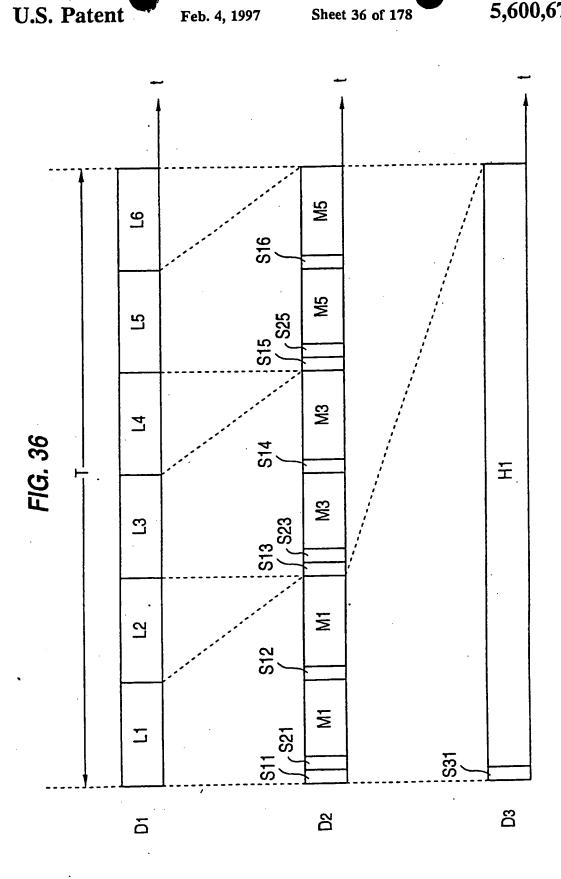












2nd MUX

COMPRESSOR

DIVIDER

INPUT

DIGITAL TRANSMITTER

COMPRESSOR

DIVIDER

INPUT

3rd MUX

COMPRESSOR

DIVIDER

INPUT

FIG. 37

TRANSMITTER

MULTIPLEXER

TRANSMIT

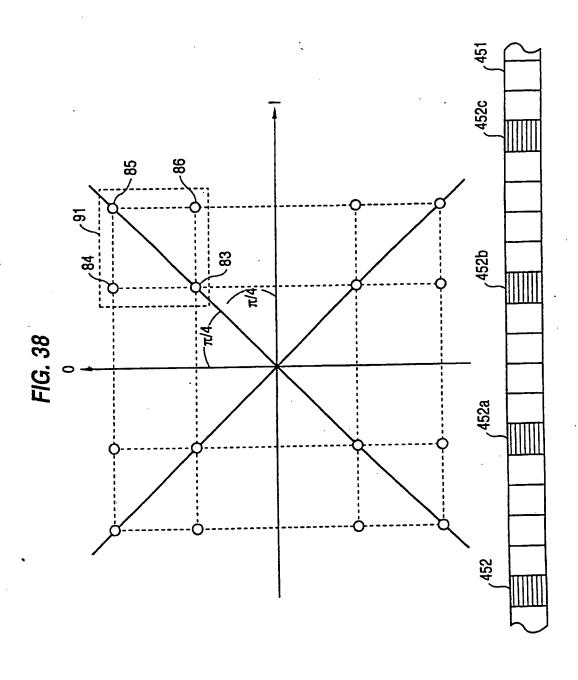
MOD

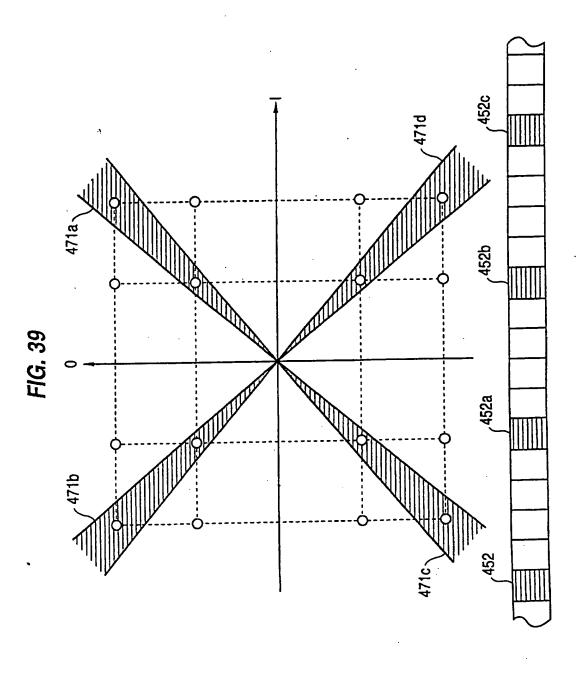
1st MUX

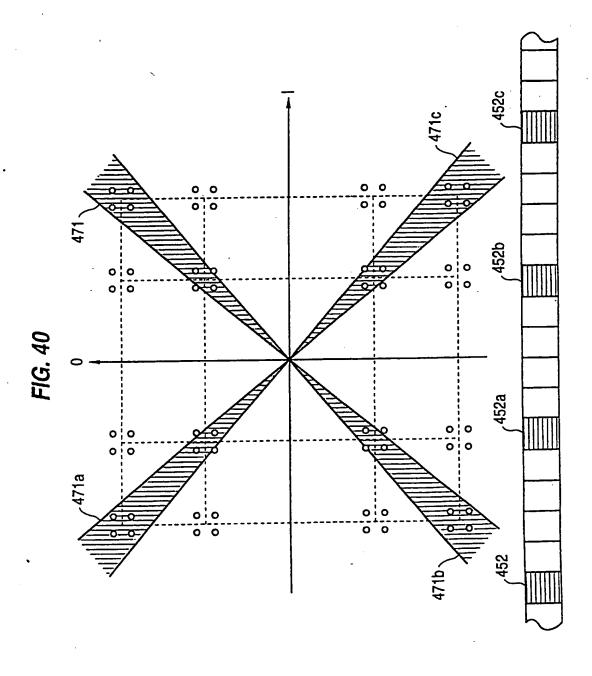
COMPRESSOR

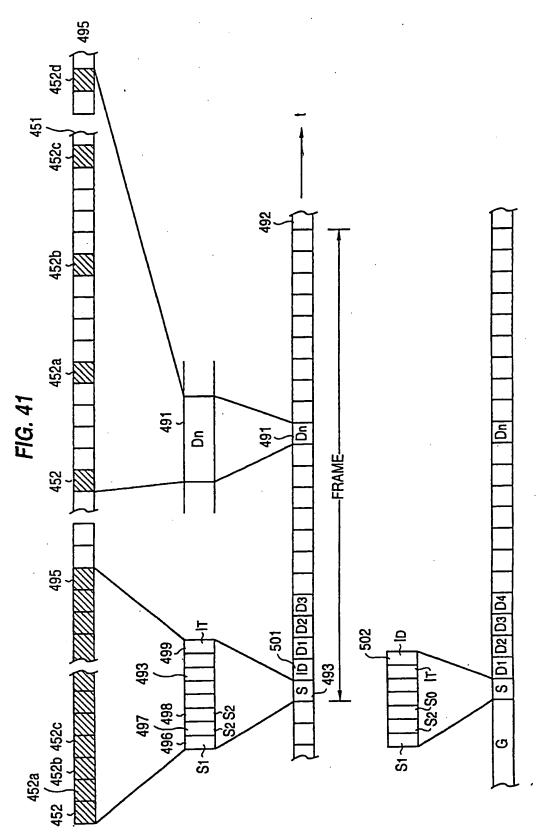
DIVIDER

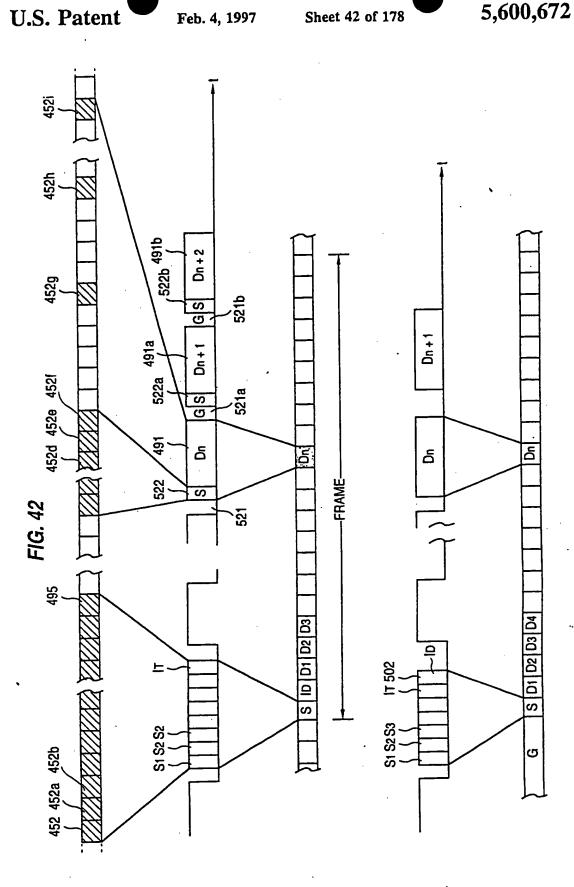
INPUT

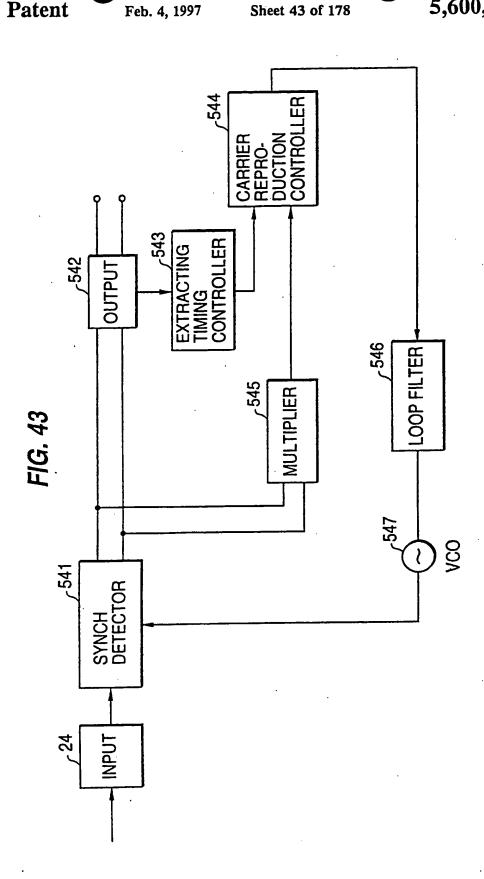


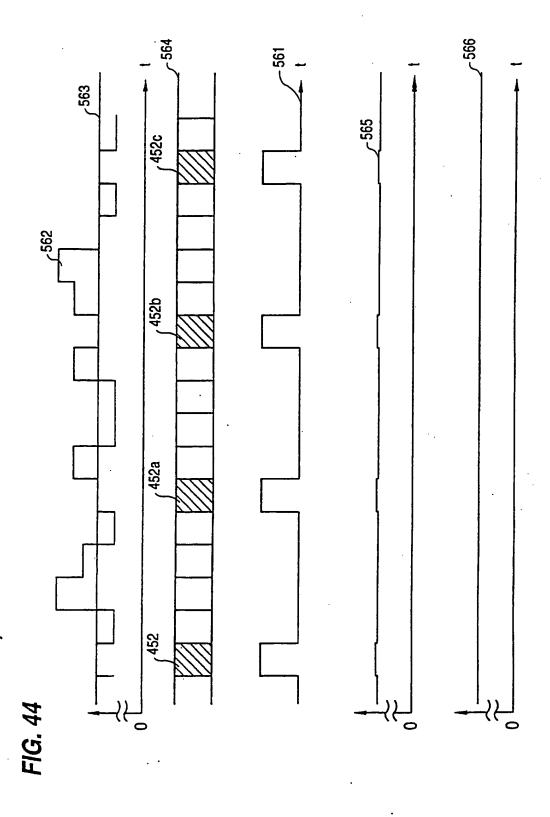




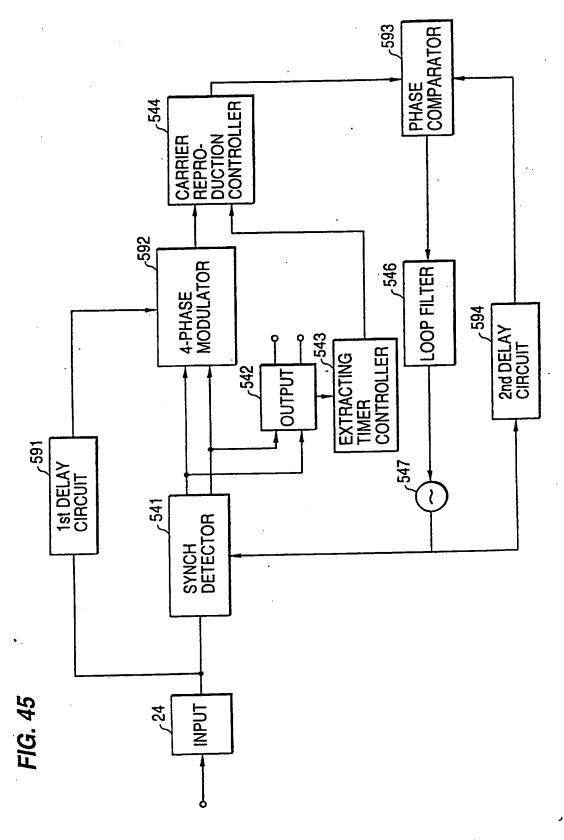


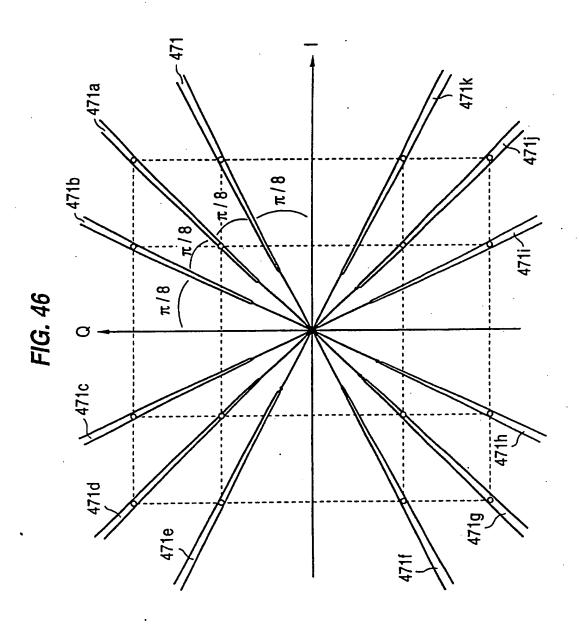


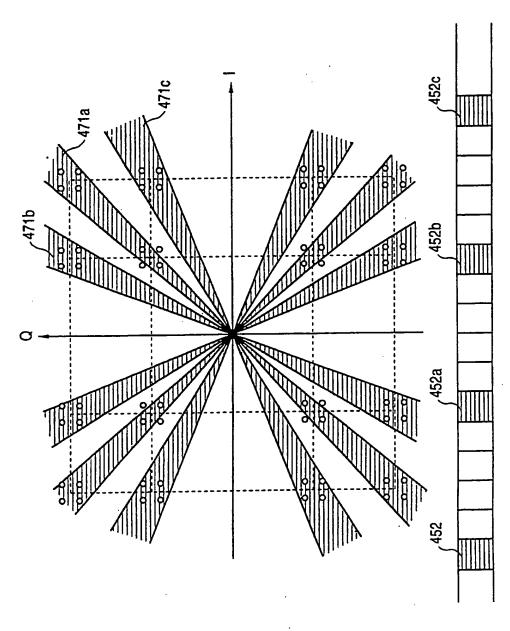












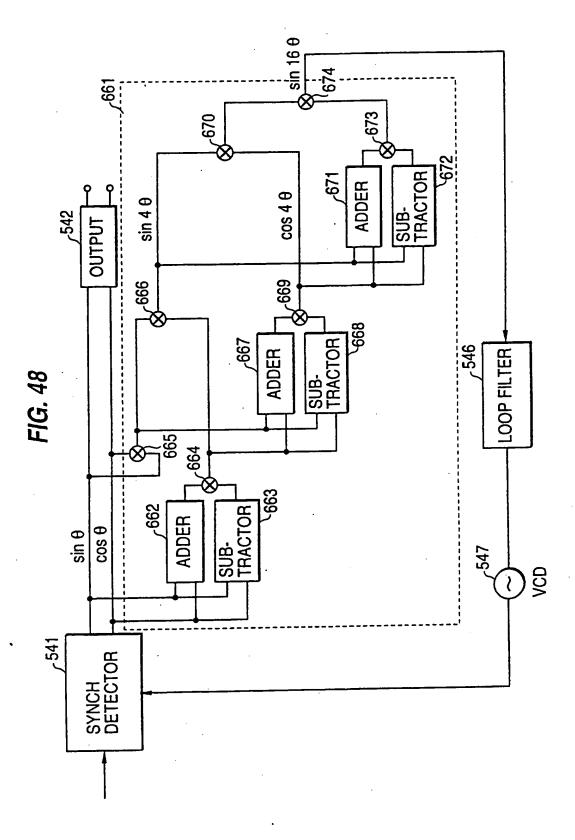
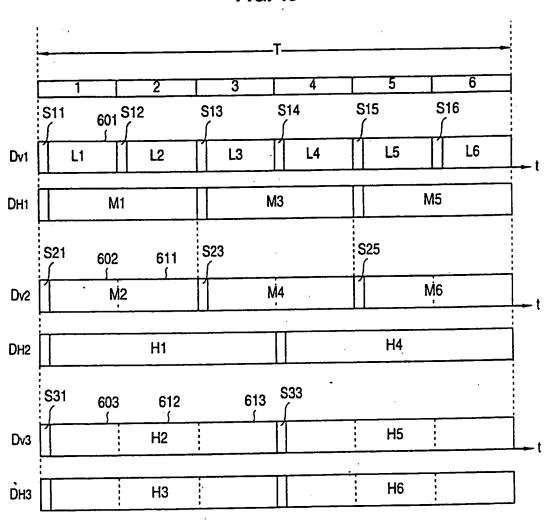
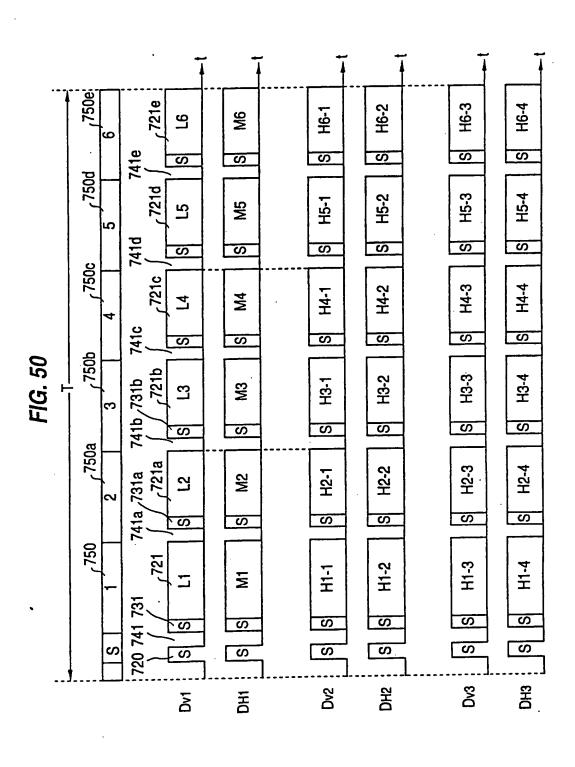
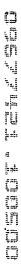


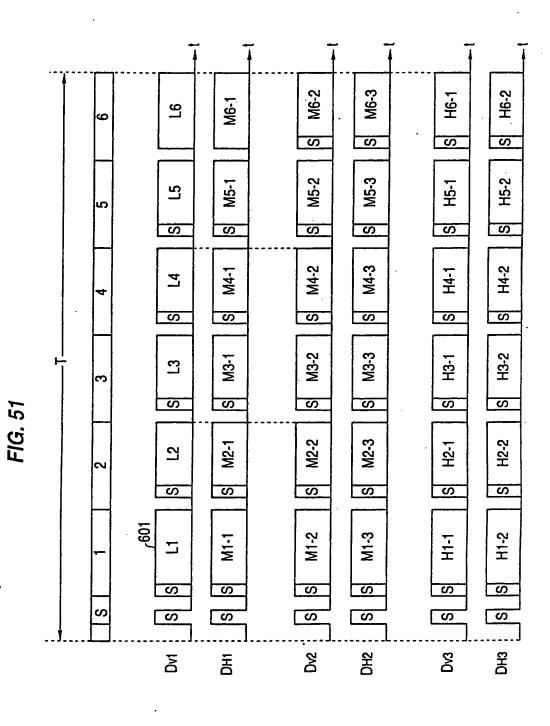
FIG. 49



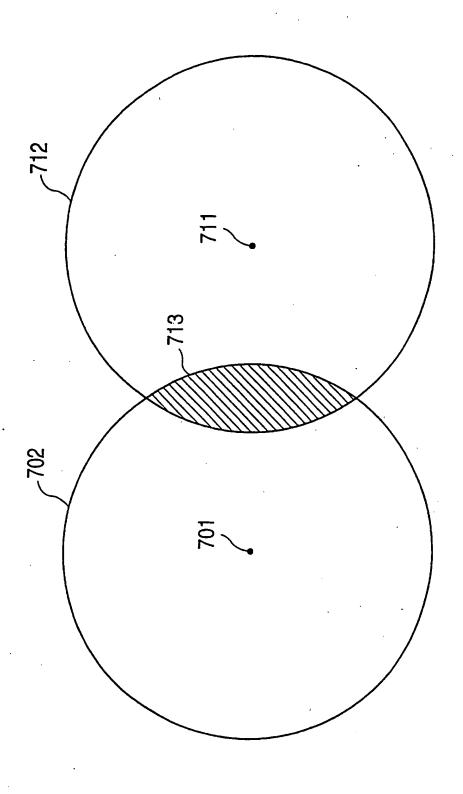
U.S. Patent



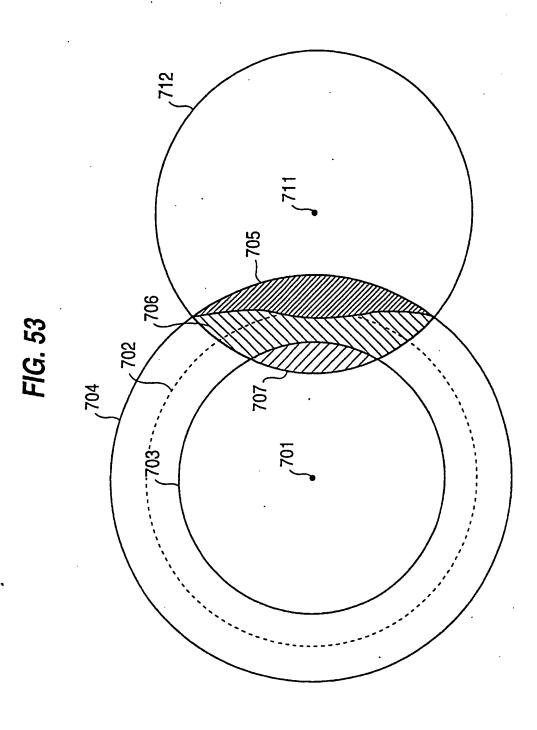




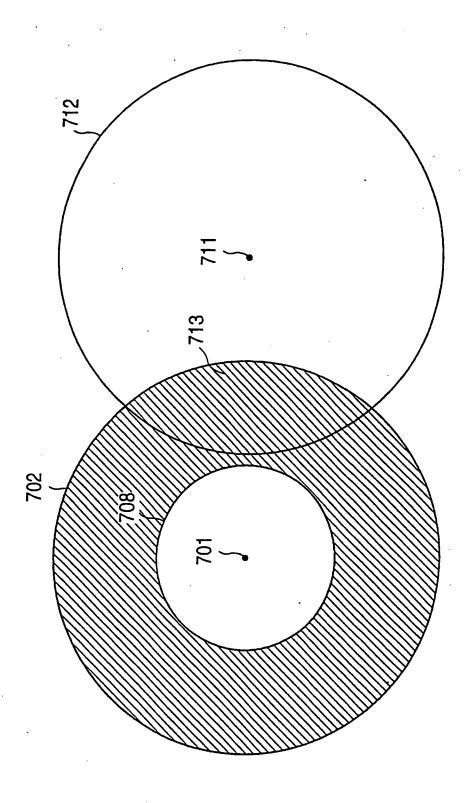


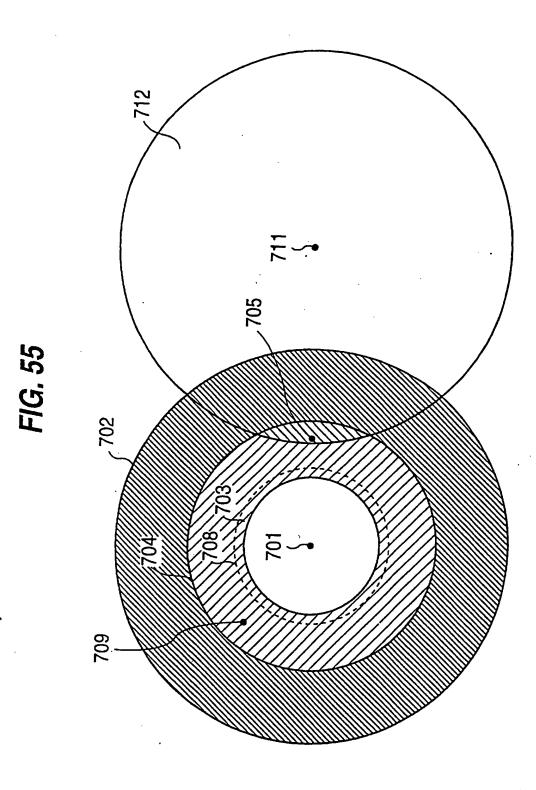


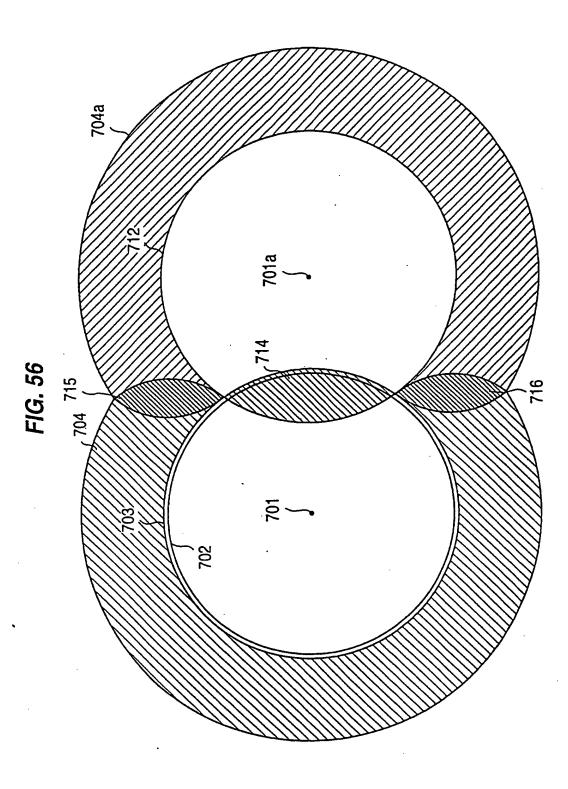














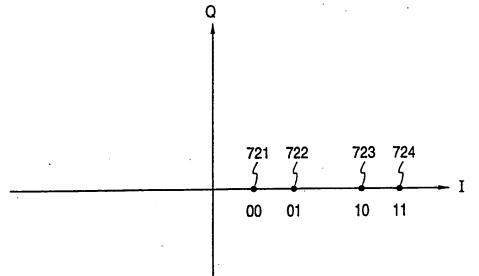
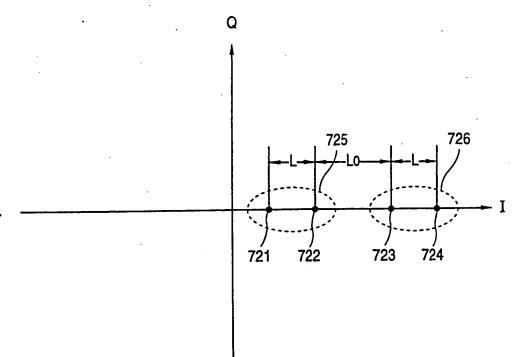
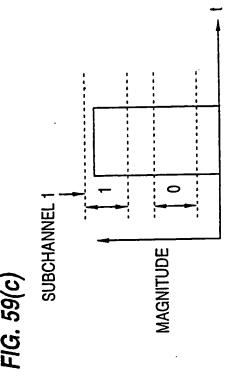


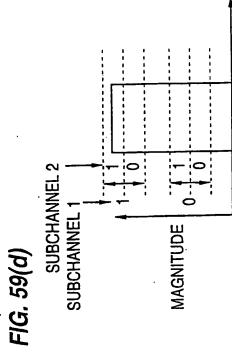
FIG. 58

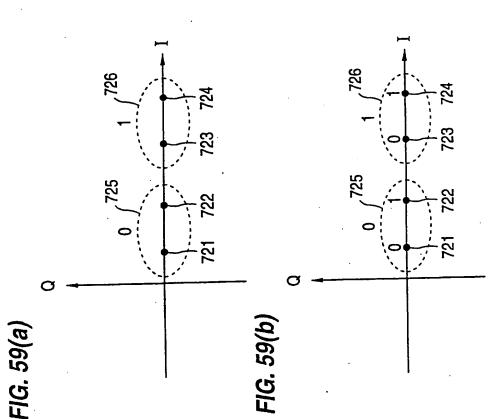


Sheet 58 of 178









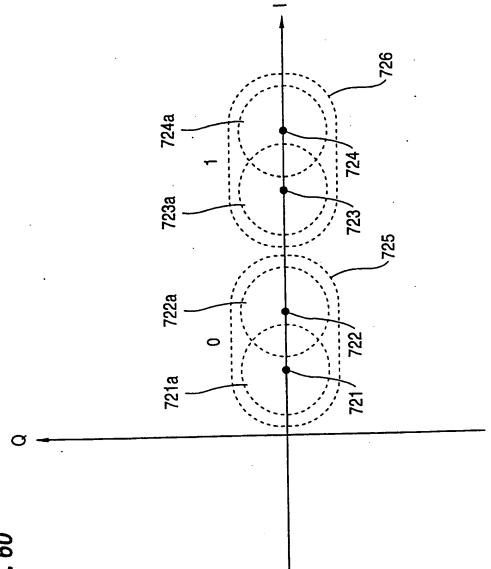
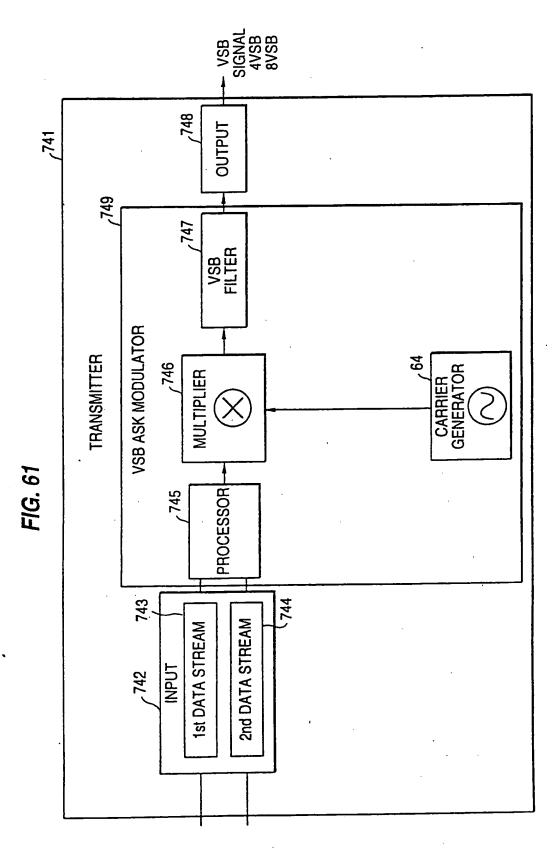
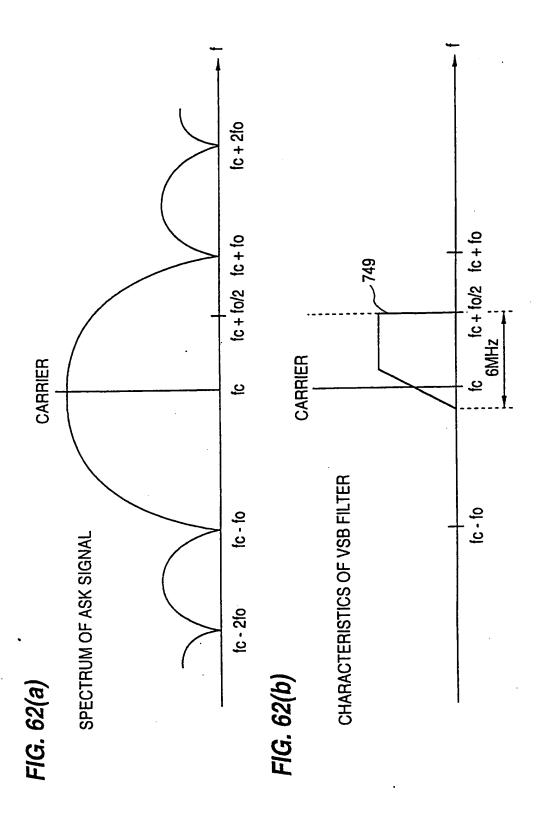


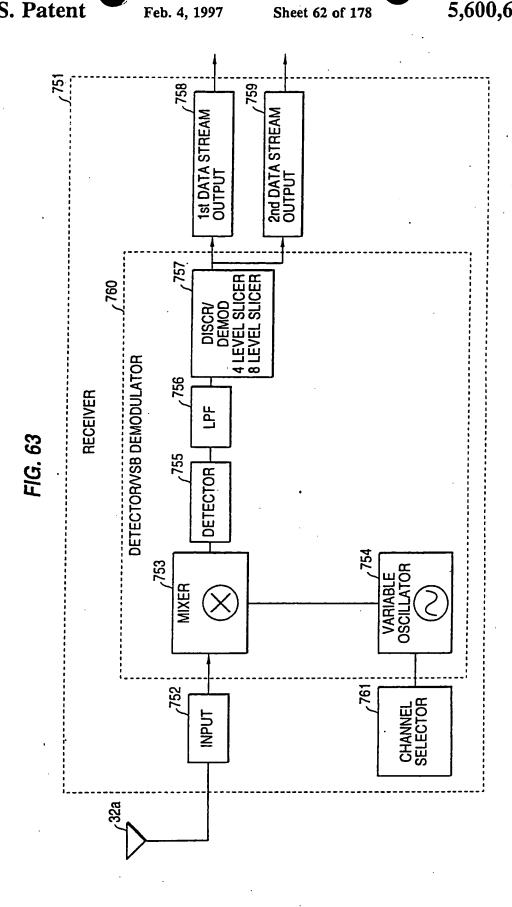
FIG. 60

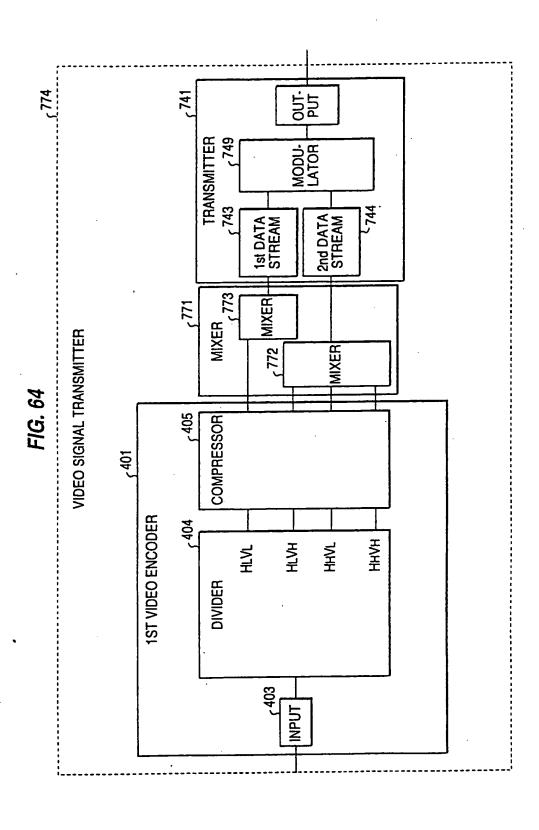
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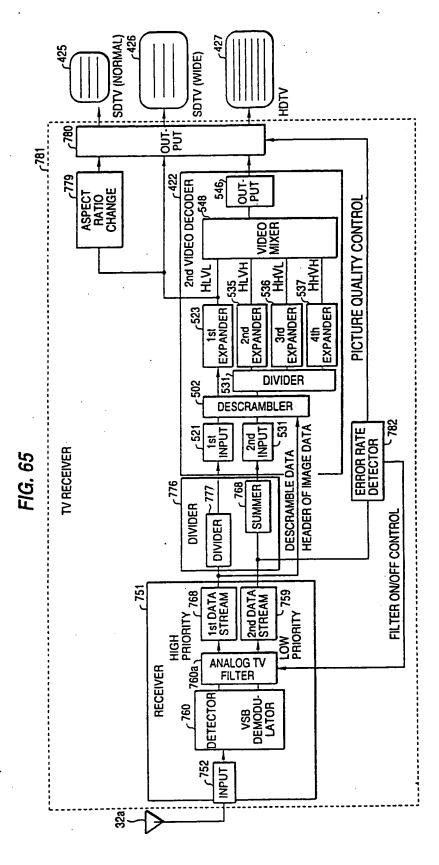


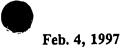


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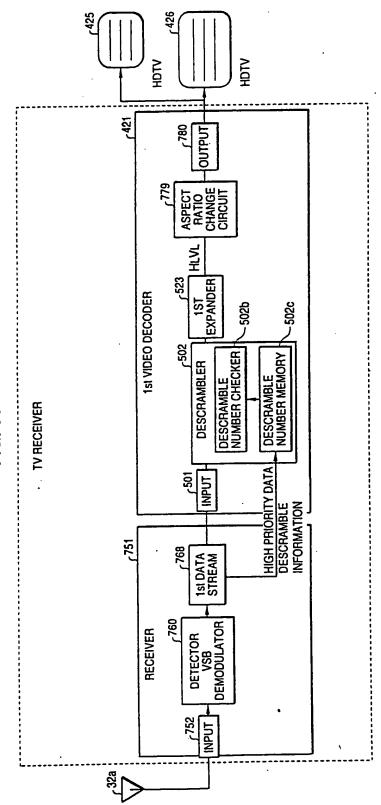
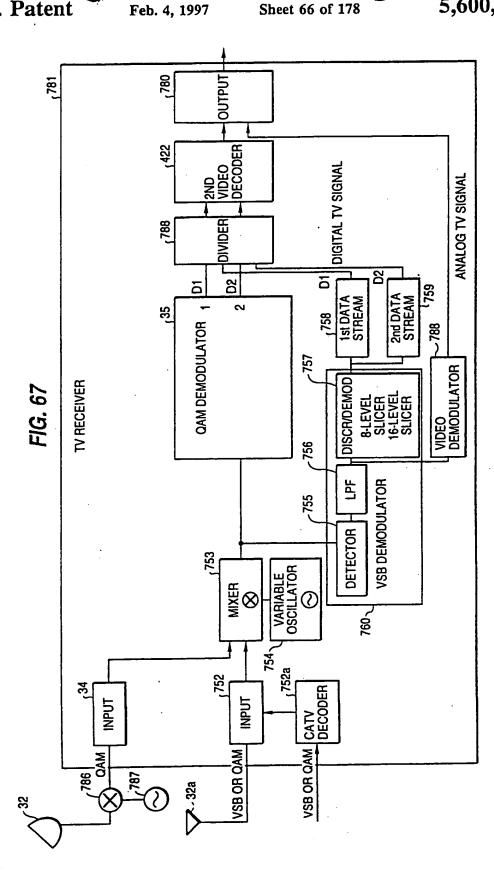
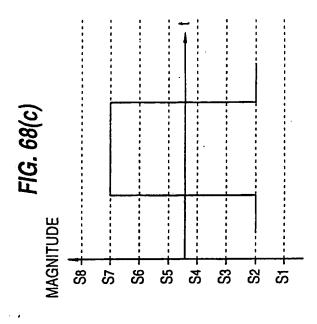
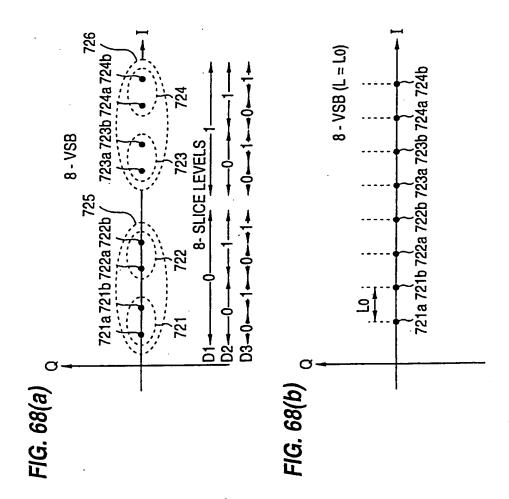


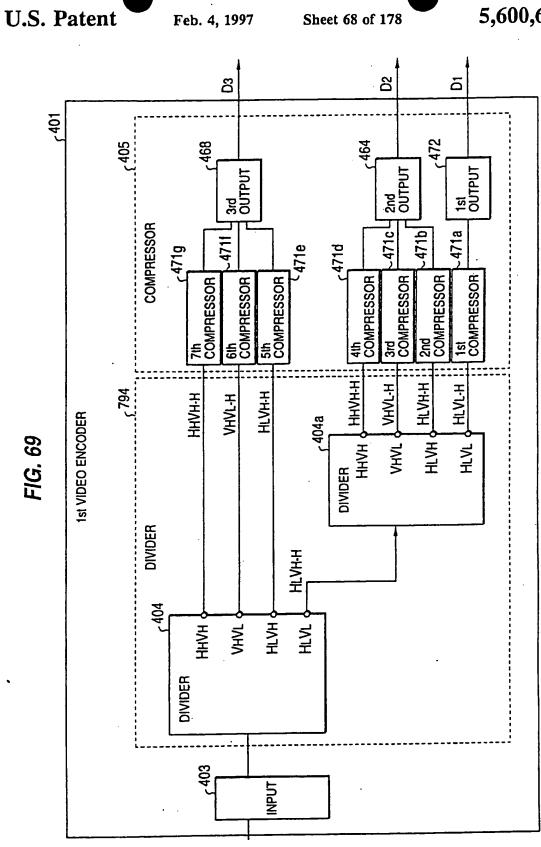
FIG. 66

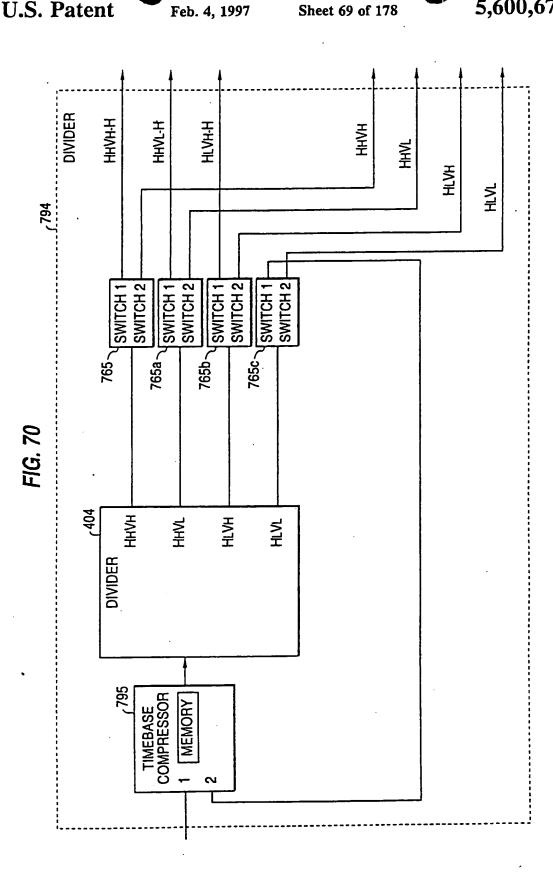




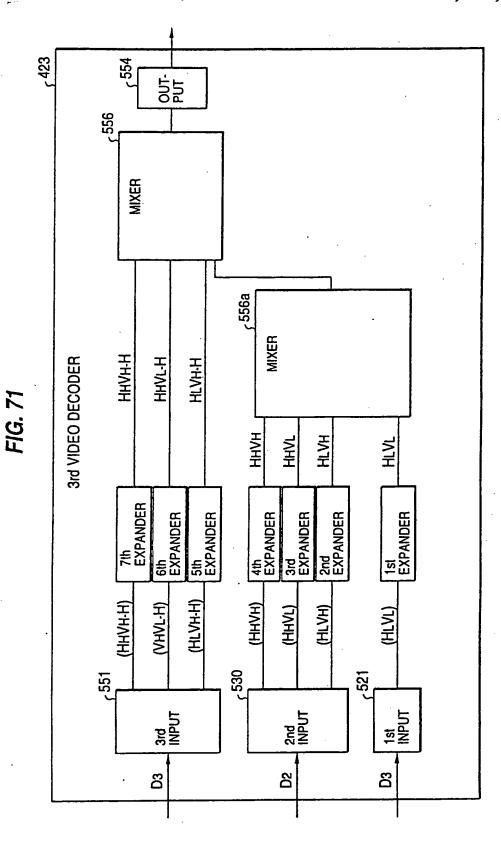


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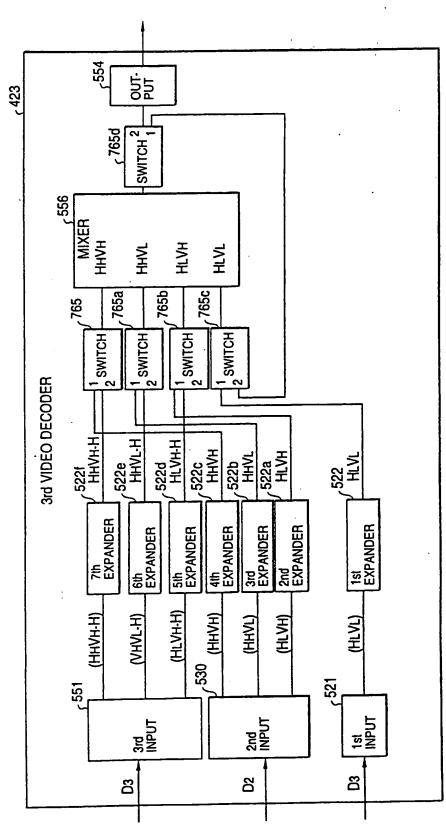
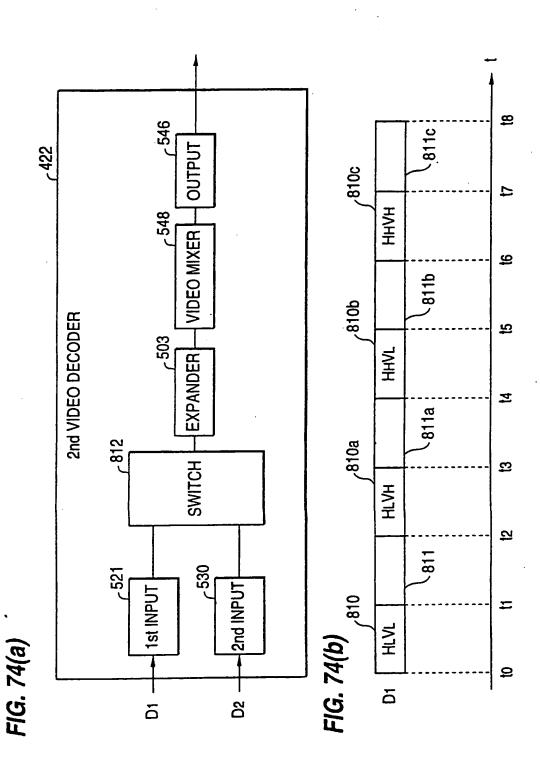


FIG. 72

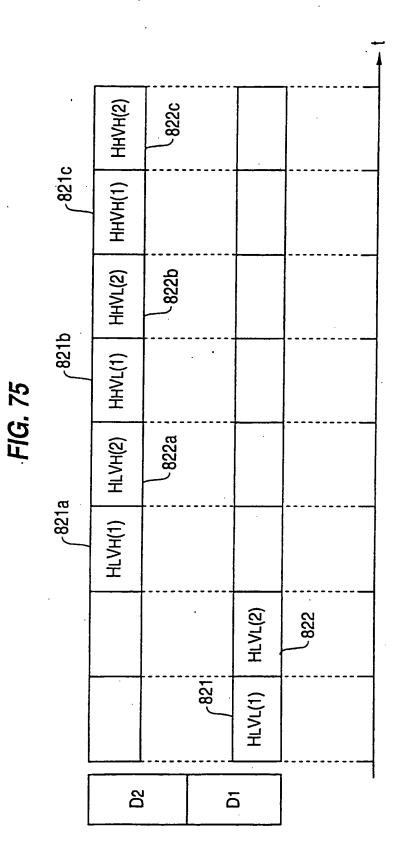
FIG. 73

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	<u> </u>	L	Jl	\$
		D1 HLVL HLVH HHVL HHVH		HLVL HLVH HHVL HHVH TIMING 1









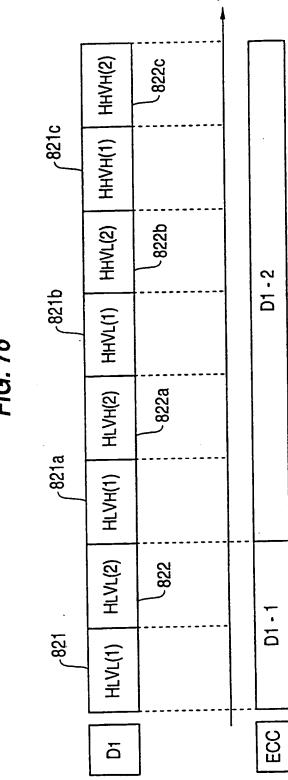
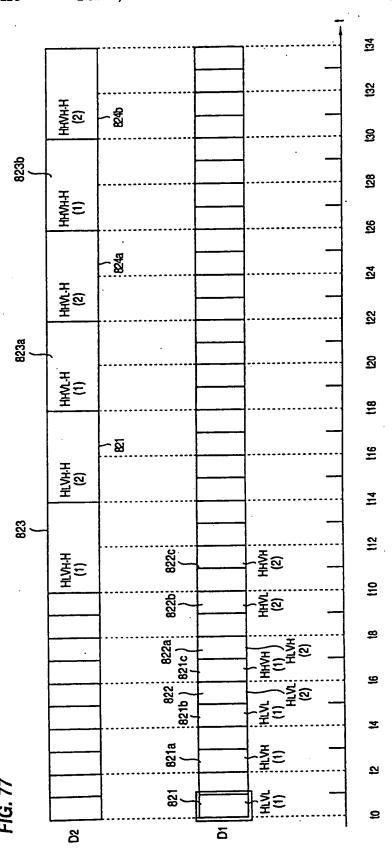
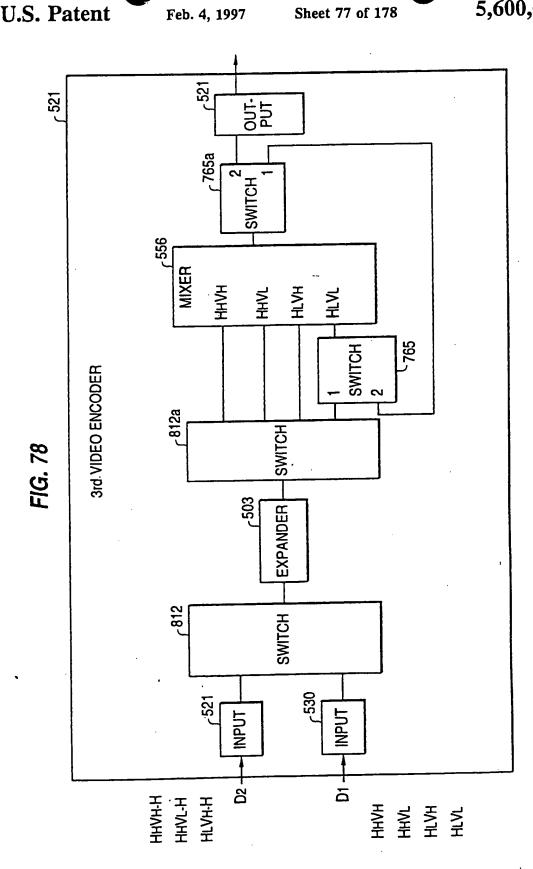
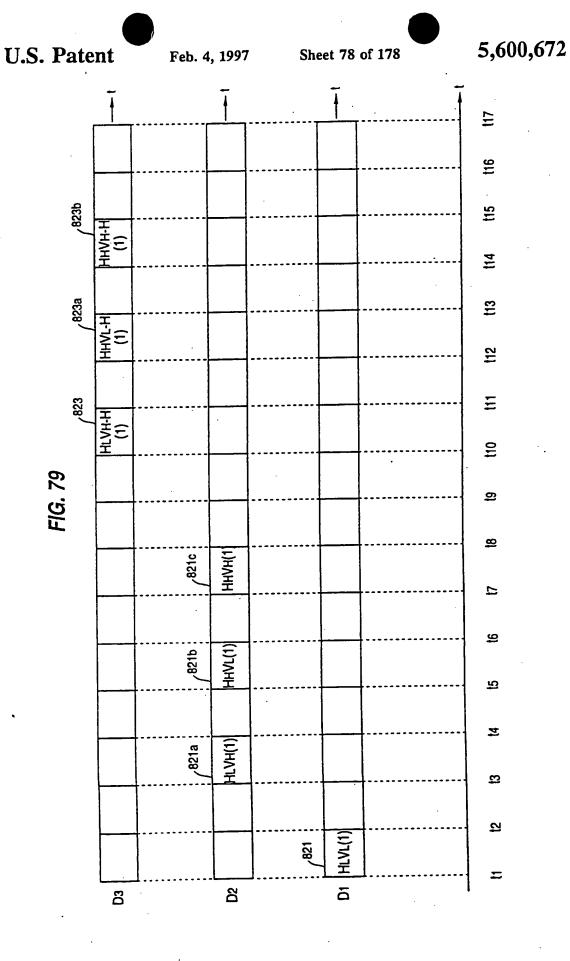
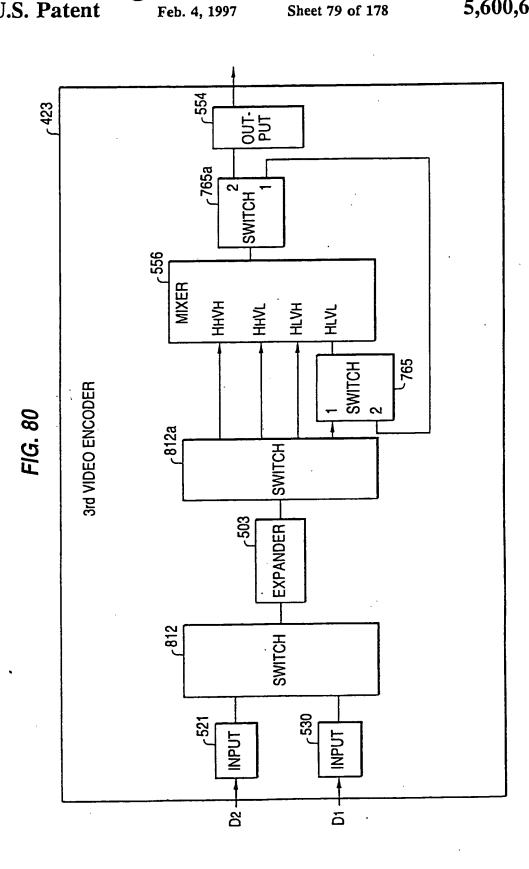


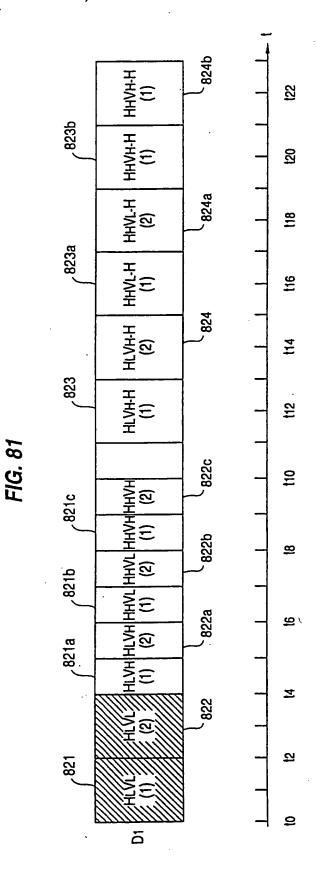
FIG. 76

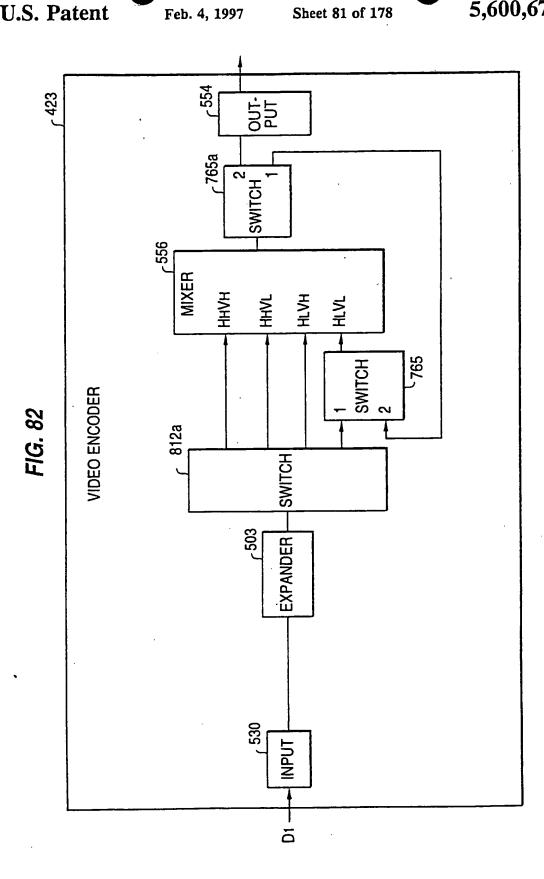


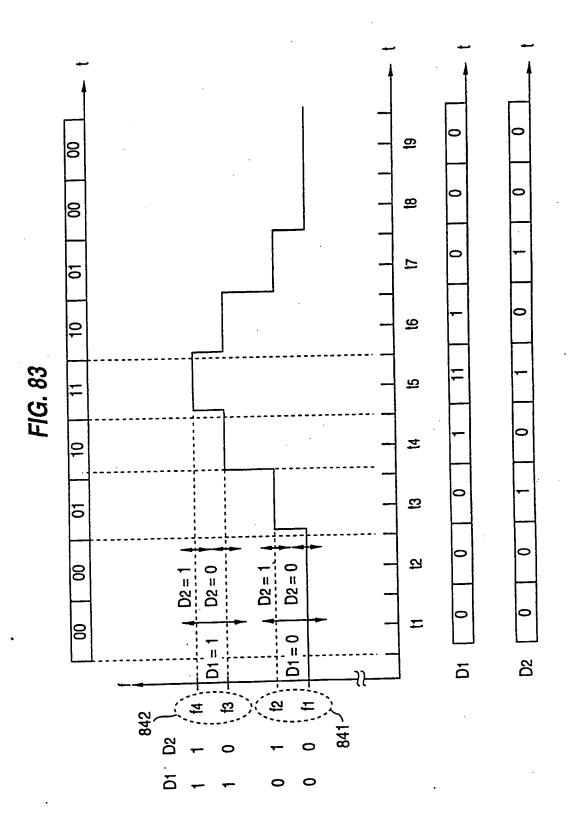


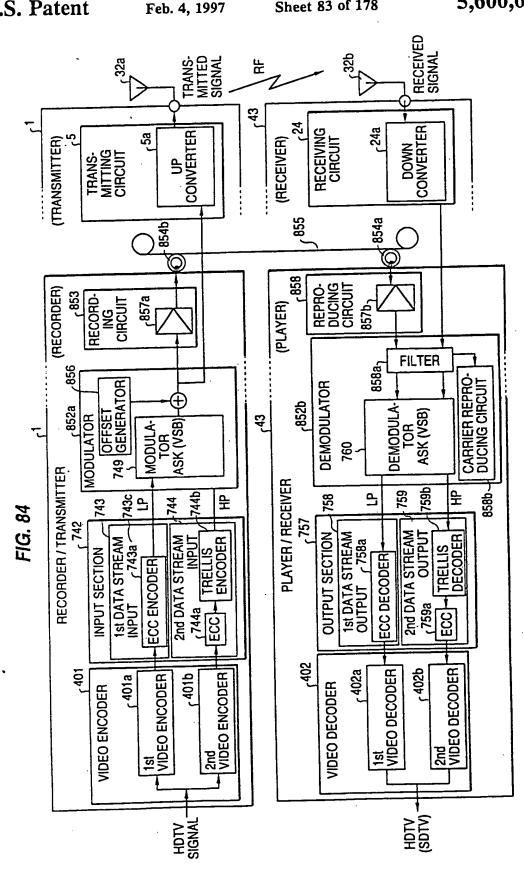


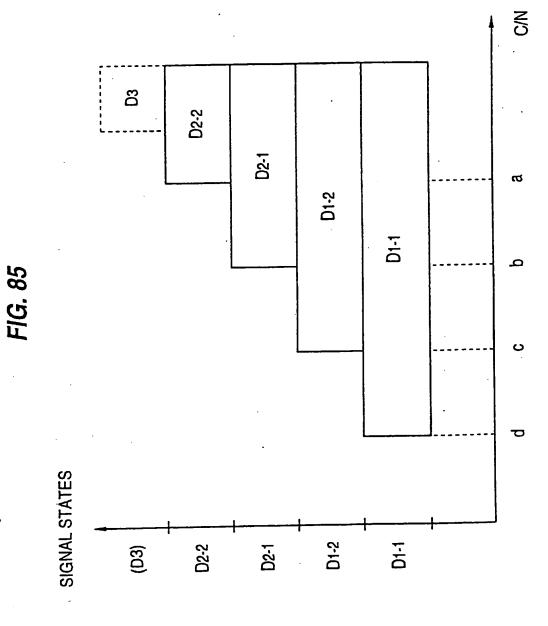




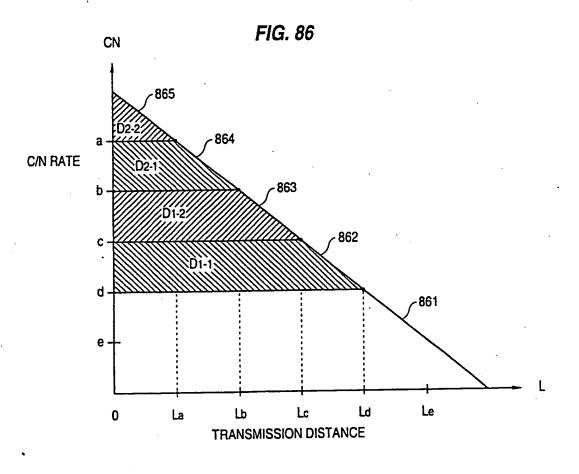


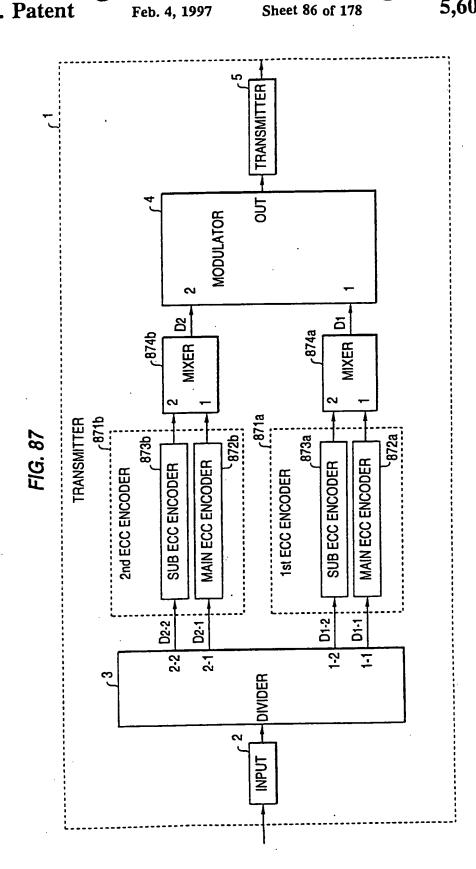












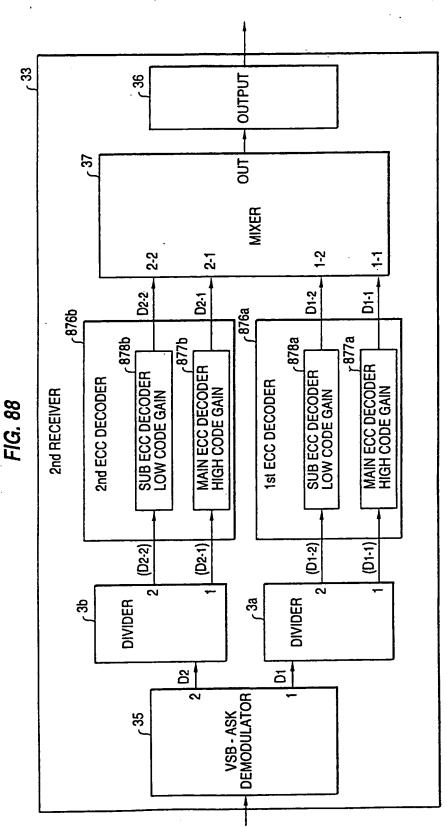
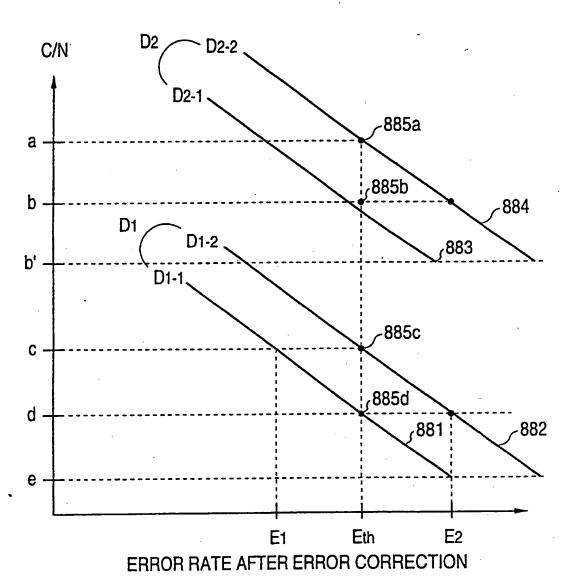
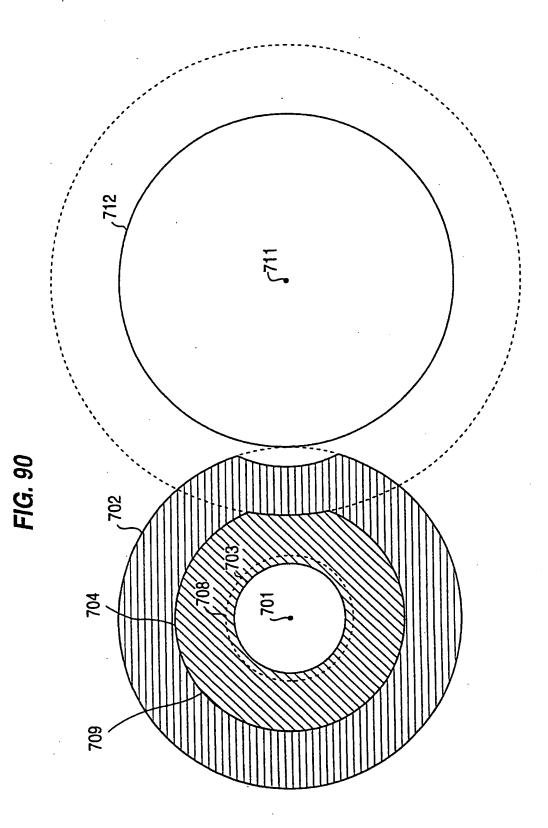


FIG. 89







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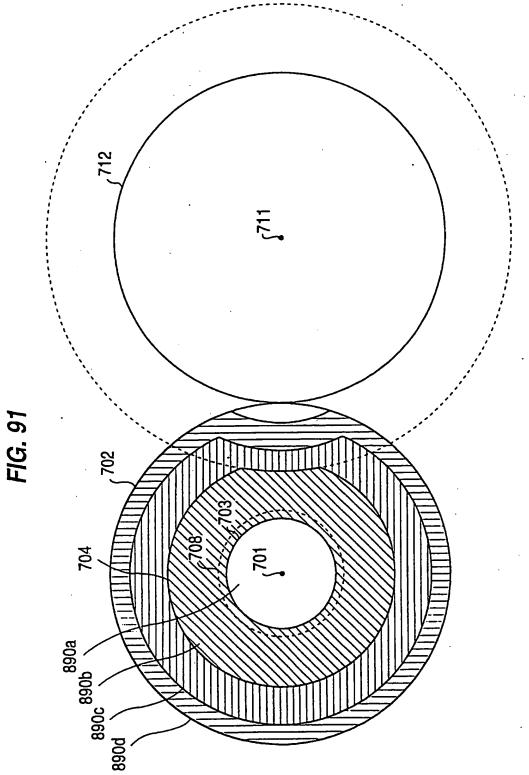
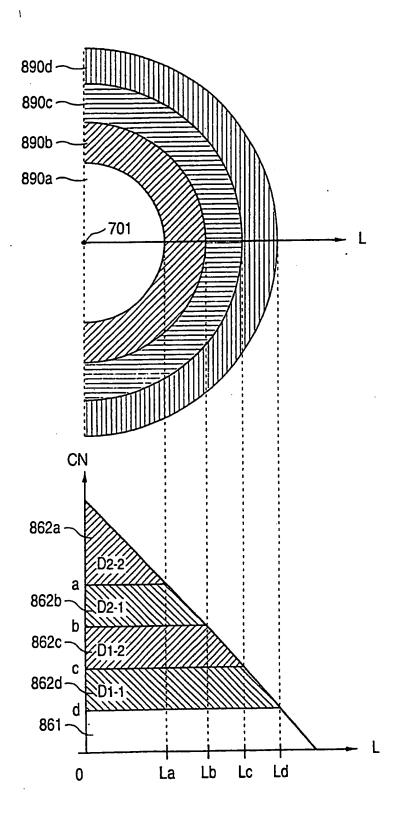
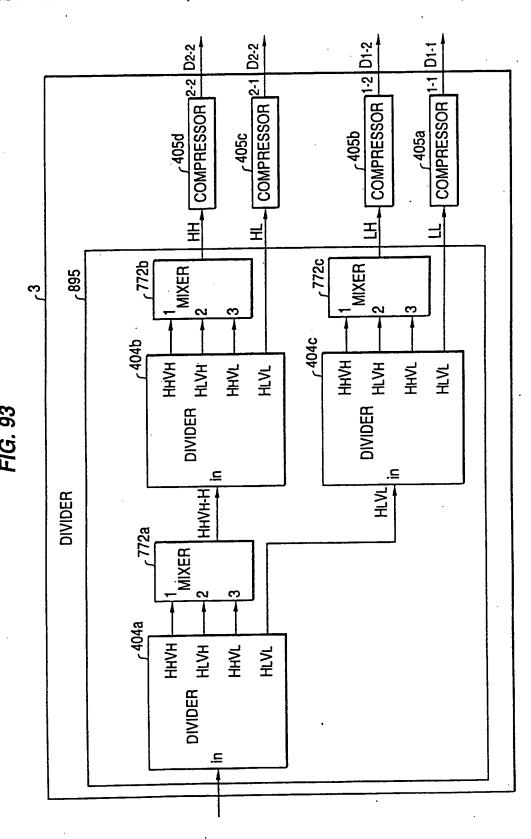
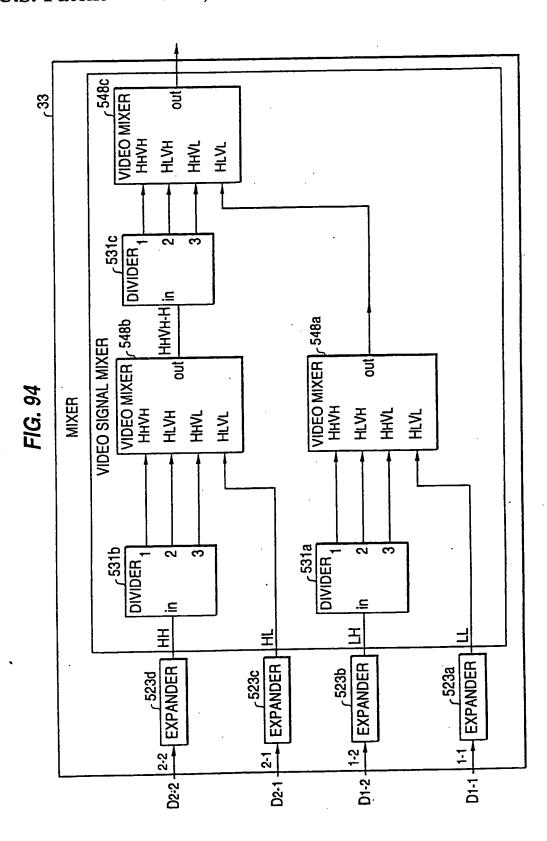


FIG. 92

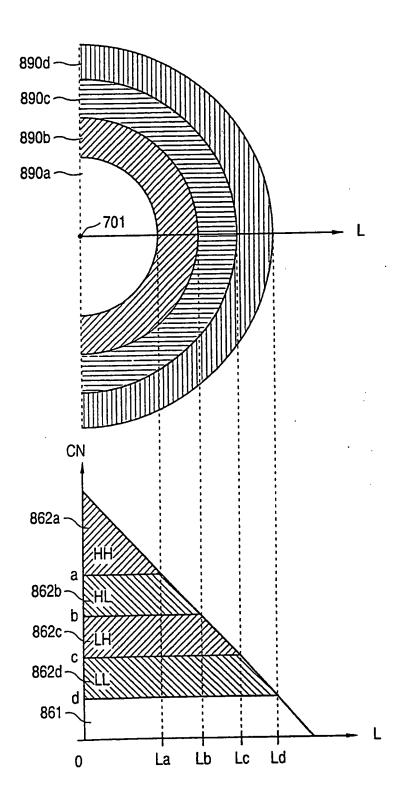


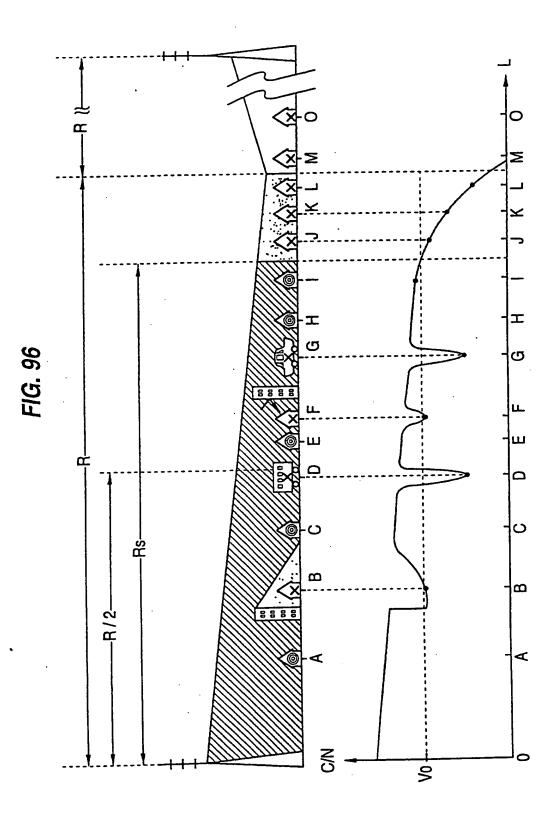


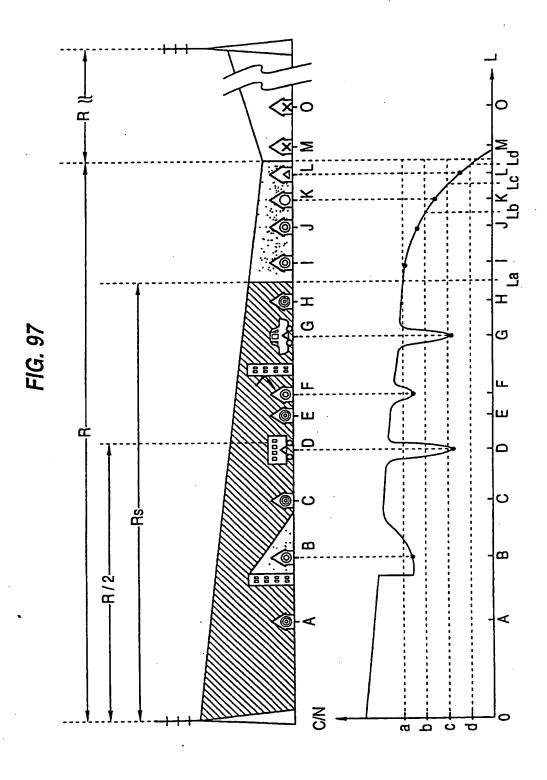


Feb. 4, 1997

FIG. 95

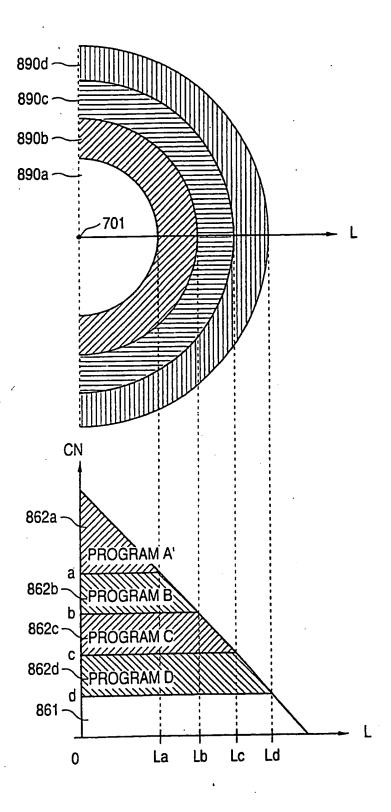






Feb. 4, 1997

FIG. 98



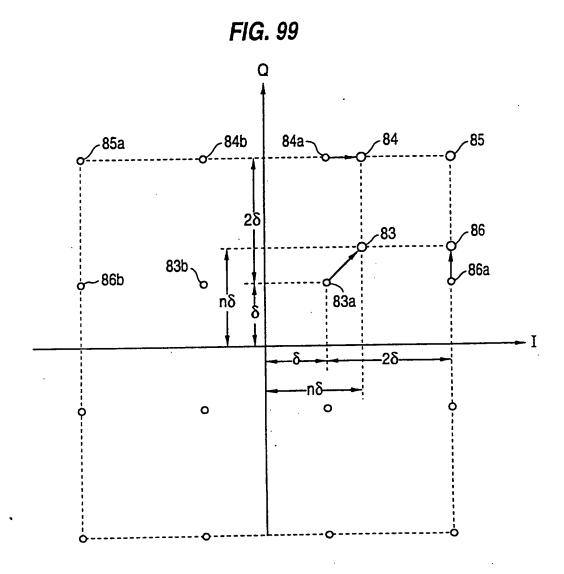
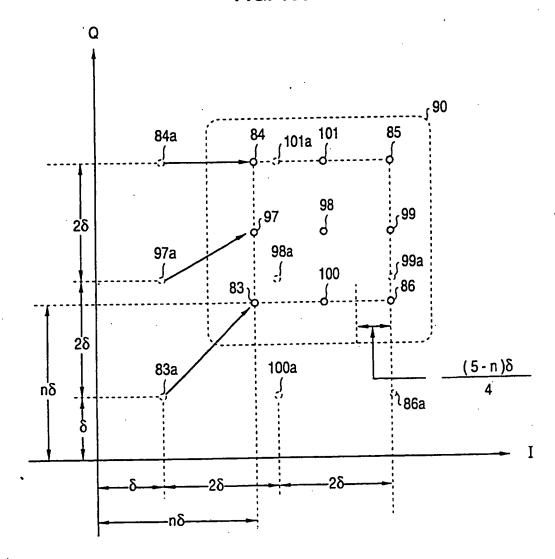
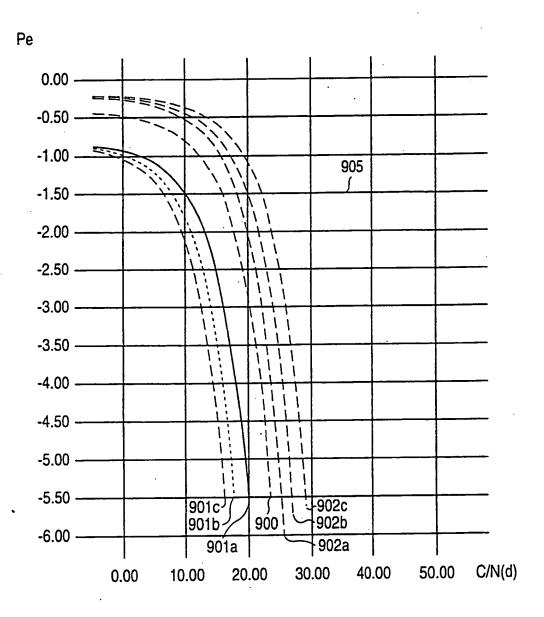


FIG. 100



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FIG. 101



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FIG. 102

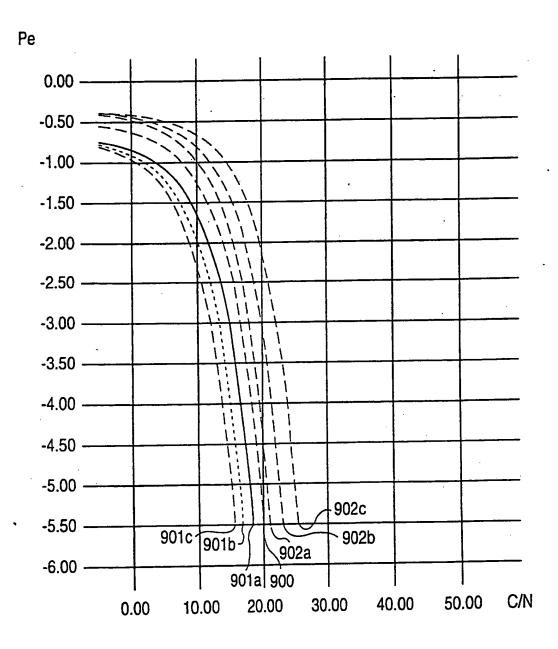
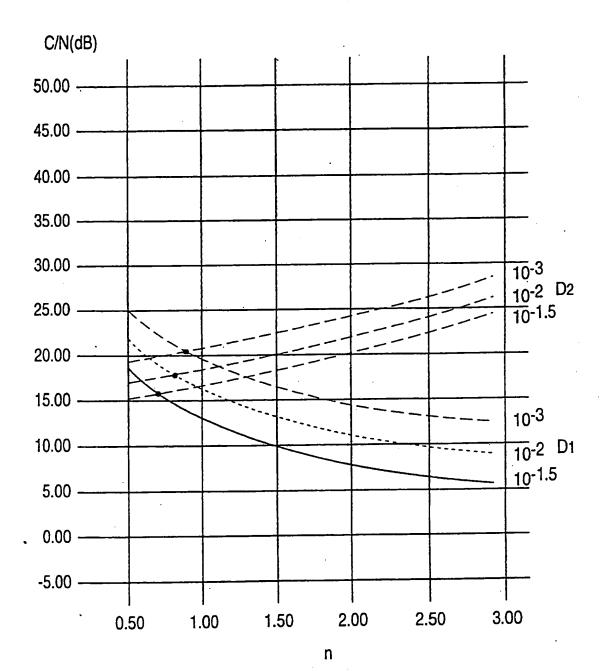
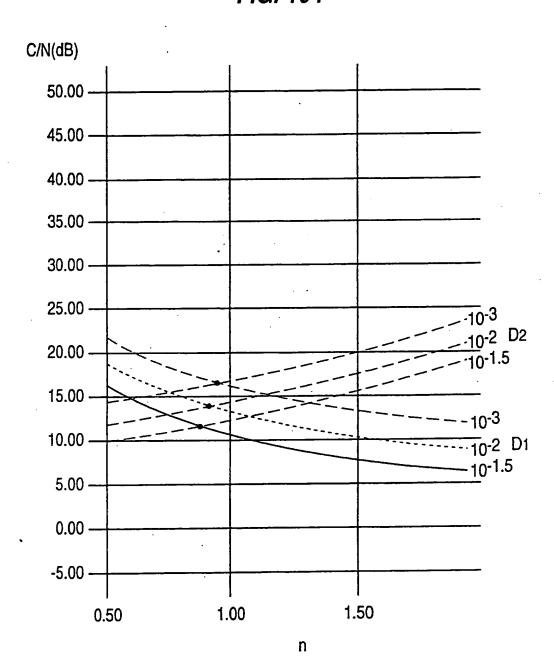


FIG. 103

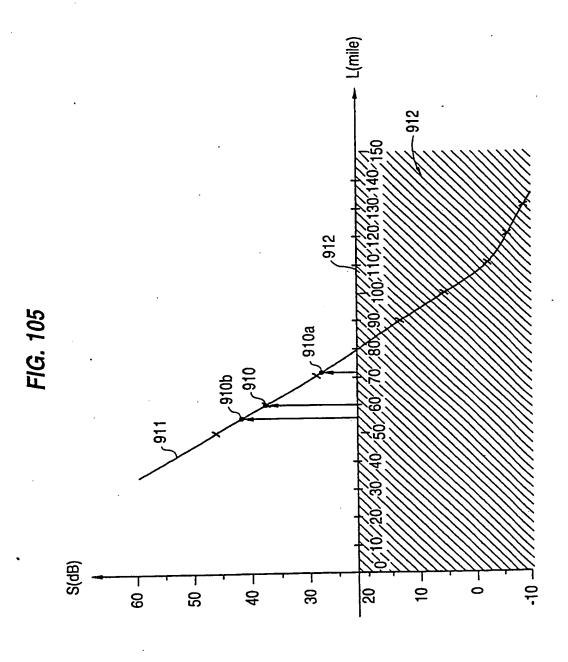


atent F

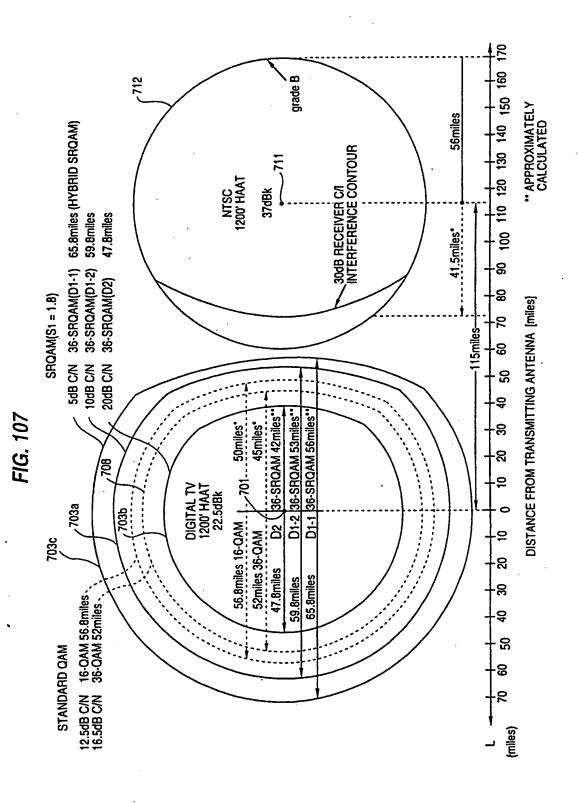
FIG. 104

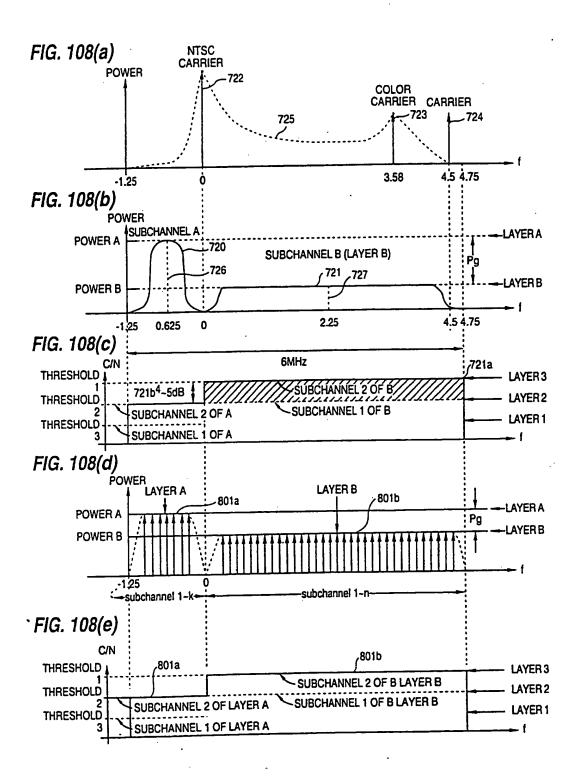


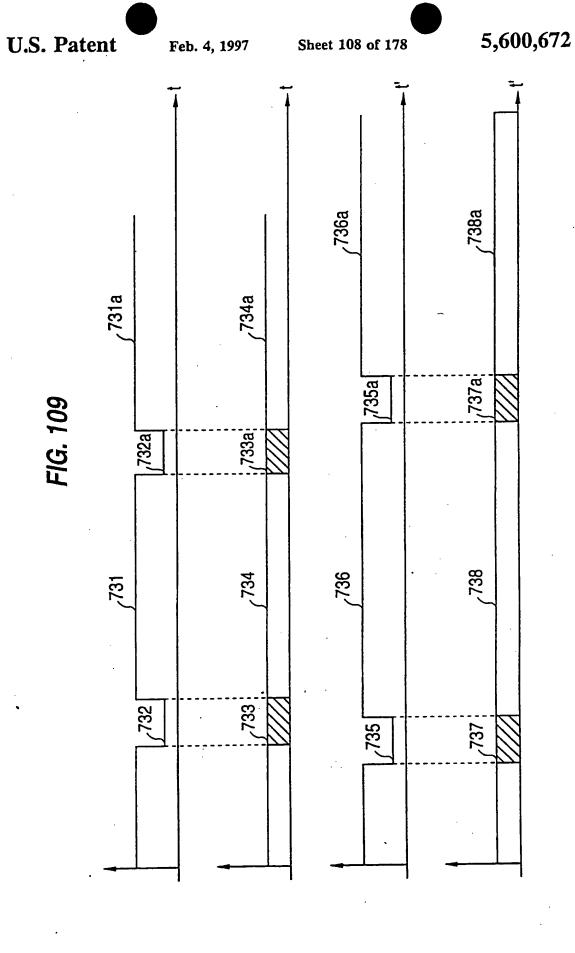


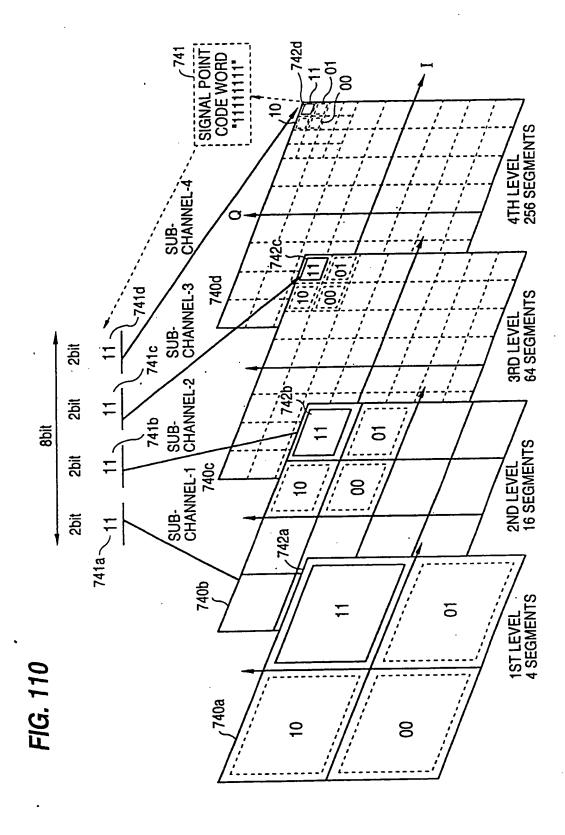


150 160 170 grade B 56miles 140 2.5dB C/N 36-SRQAM(D1-1) 70.4miles (HYBRID SRQAM) 30dB RECEIVER C/I INTERFERENCE CONTOUR 29 NTSC 1200' HAAT 100 110 120 37dBk 62.8miles 44.8miles 41.5miles* 8 36-SRQAM(D1-2) 36-SRQAM(D2) 8 DISTANCE FROM TRANSMITTING ANTENNA [miles] SROAM(S = 2.5)-115miles-ස - 7.5dB C/N 22.5dB C/N വ D1-2 36-SROAM 54miles** 36-SRQAM 56miles** 36-SROAM 39miles FIG. 106 45miles* -701...50miles* ഉ ಣ DIGITAL TV 1200' HAAT 22.5dBk 703a 703b 56.8miles 16-QAM 52miles 36-QAM 2 **703**c ಜ 44.8miles 62.8miles 70miles ဗ္ဗ 16-QAM 56.8miles . 36-QAM 52miles . \$ ည STANDARD QAM ස 12.5dB C/N 16.5dB C/N (miles)









The first that that that the

FIG. 111

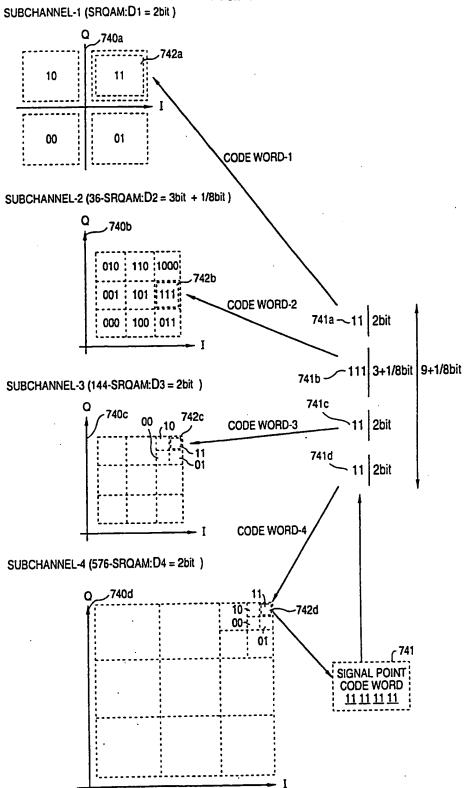
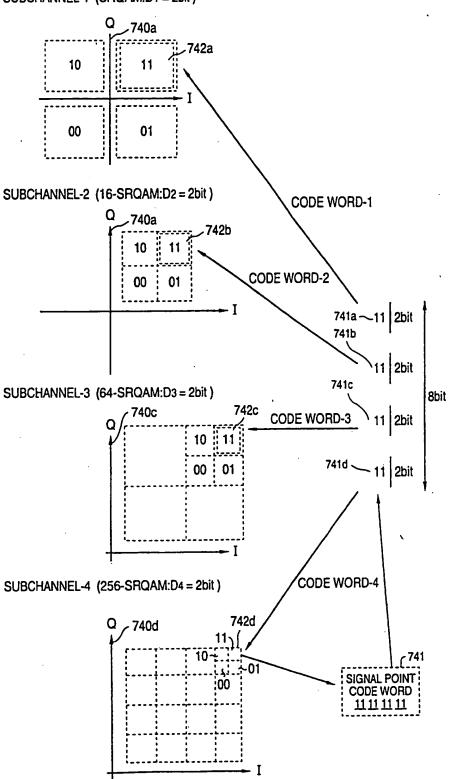
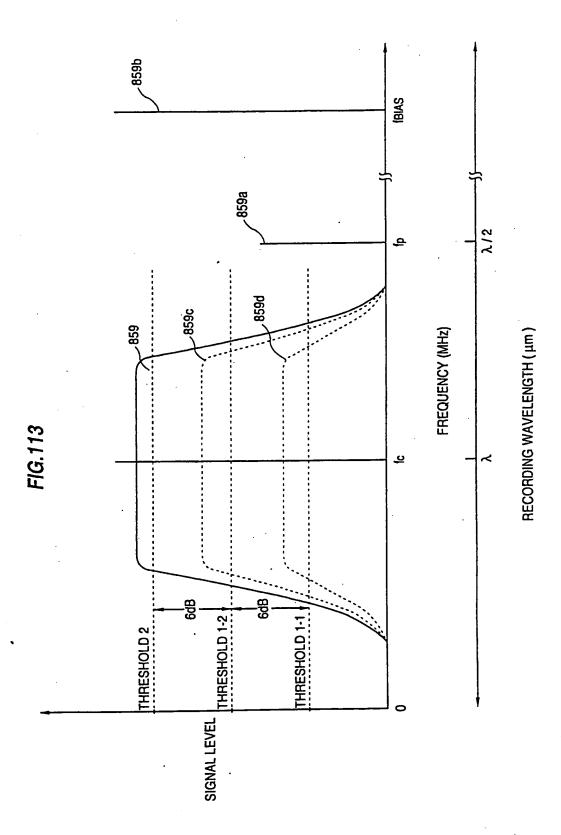


FIG. 112

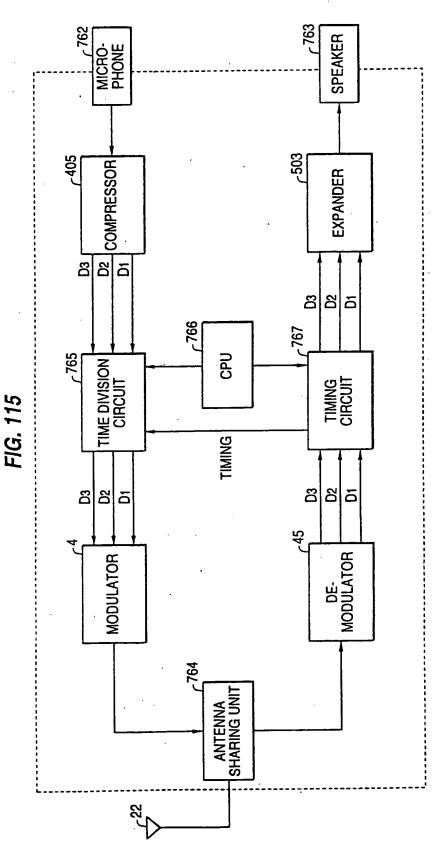
SUBCHANNEL-1 (SRQAM:D1 = 2bit)

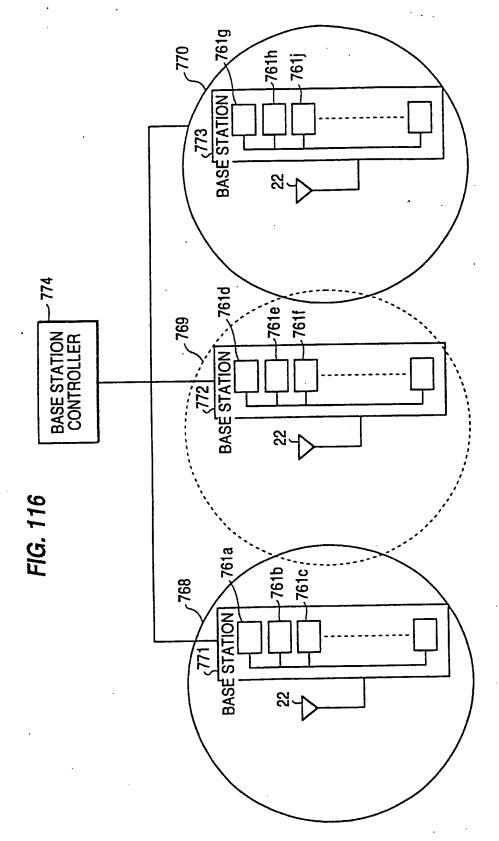


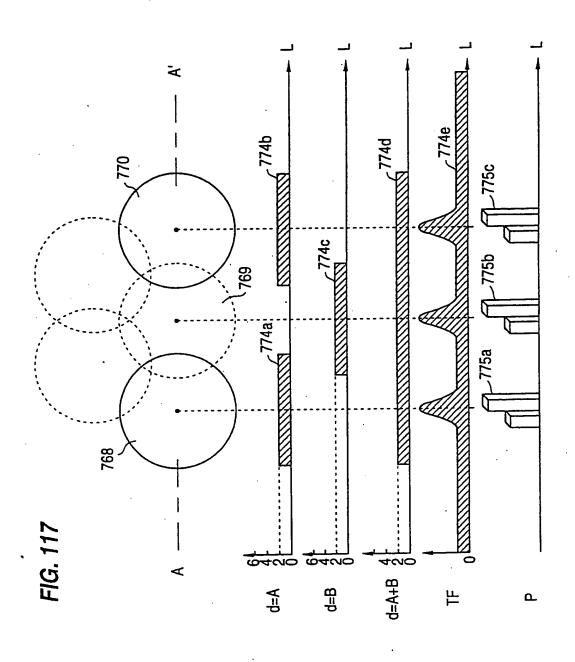
Sheet 112 of 178

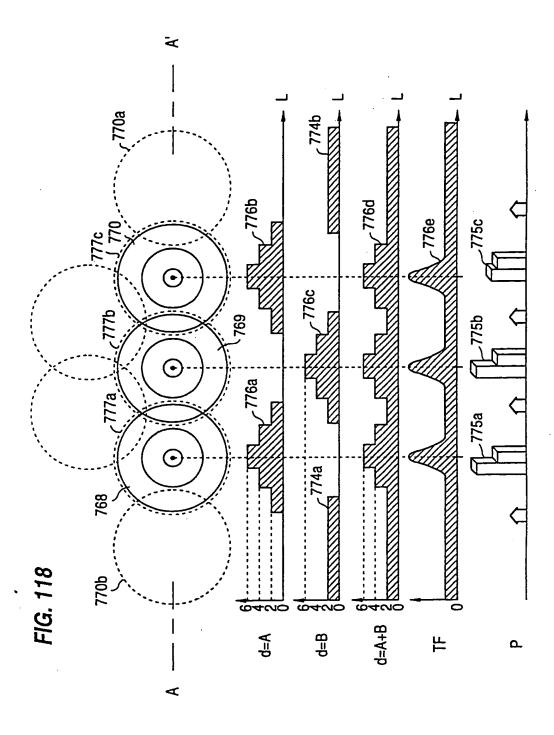


5,600,672 U.S. Patent Sheet 113 of 178 Feb. 4, 1997 851 RECORDING PLAYBACK CARRIER REPRODUCTION BIAS GENERATOR FILTER 858b 160 CARRIER MODULATOR /DEMODULATOR DE-MODULATOR MODULATOR မြ MAGNETIC RECORDING / PLAYBACK APPARATUS FIG. 114 5 OUTPUT SECTION 758 1ST DATA STREAM OUTPUT 1ST DATA STREAM INPUT INPUT SECTION 742 422a 401a 422 **1ST VIDEO DECODER** 1ST VIDEO ENCODER VIDEO DECODER **VIDEO ENCODER**

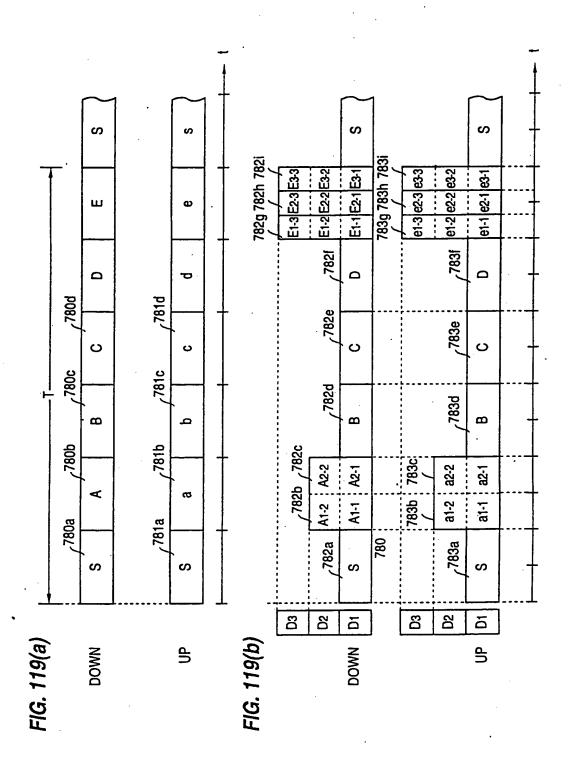


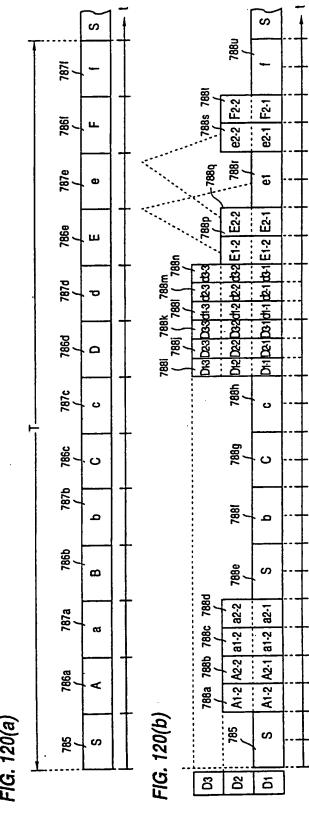




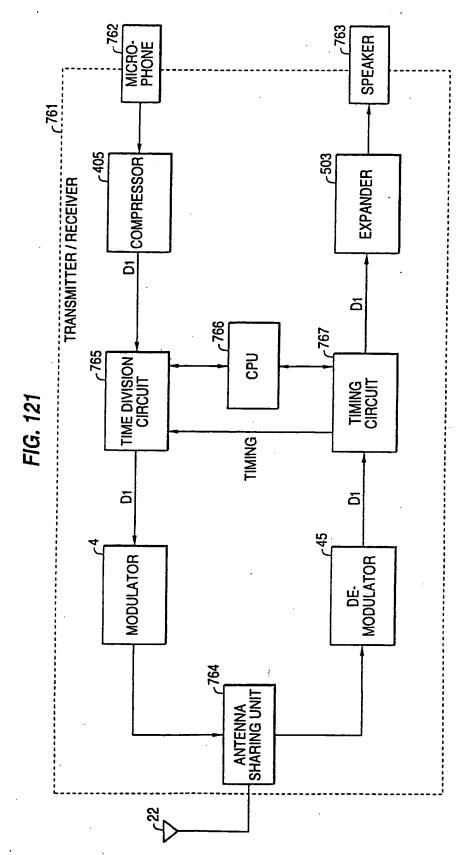


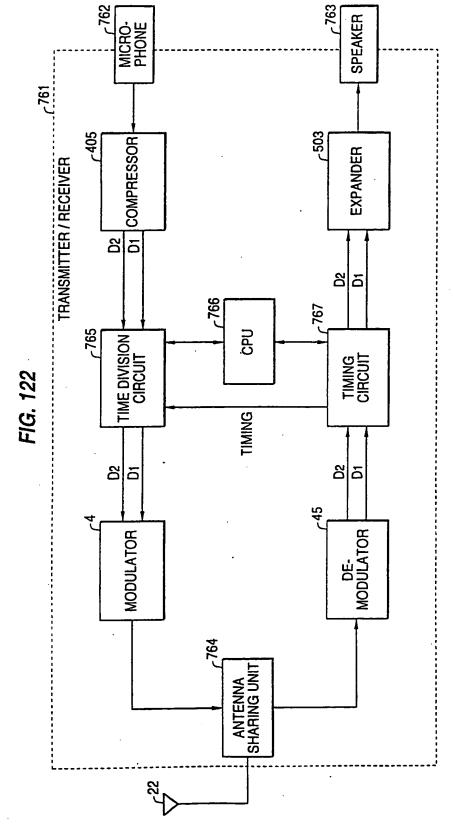






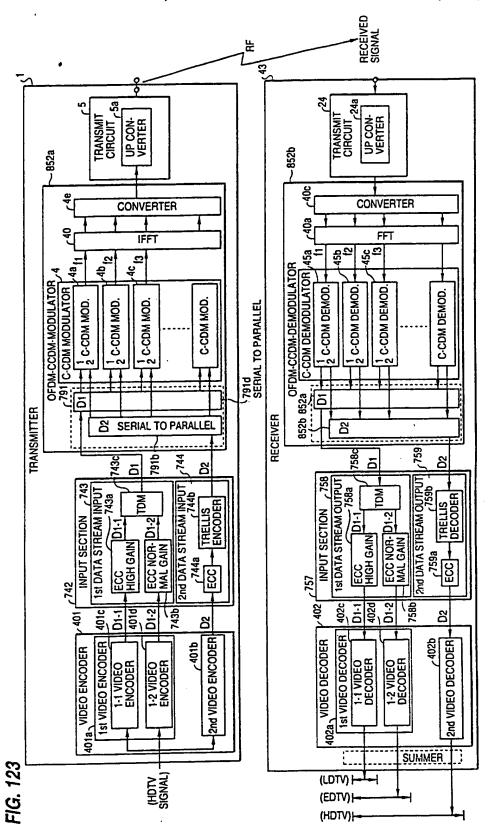
U.S. Patent Feb. 4, 1997 Sheet 120 of 178 5,600,672

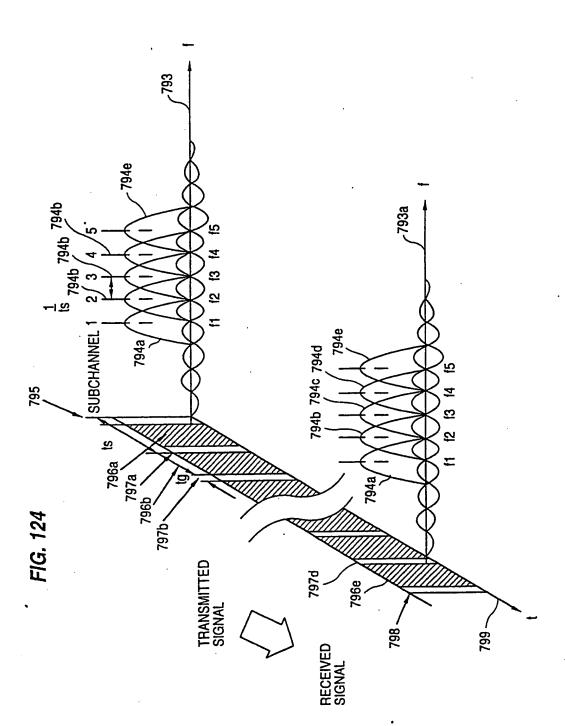




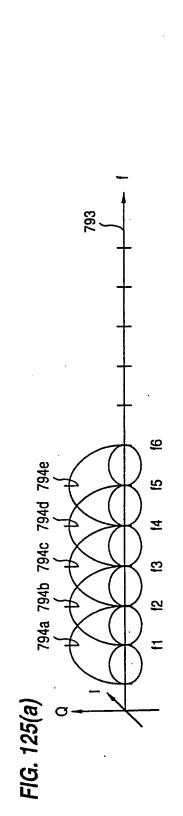
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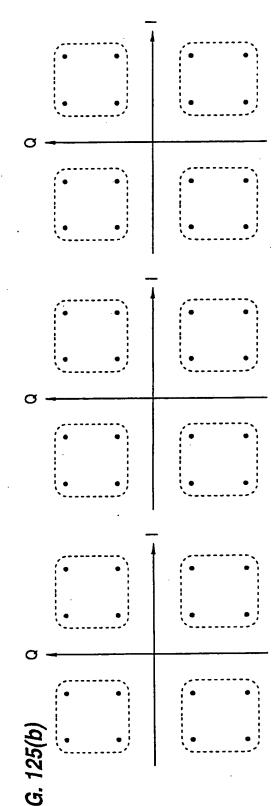
Sheet 122 of 178

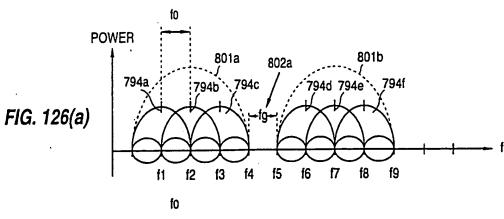


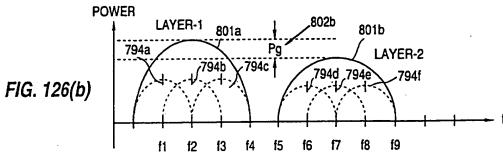


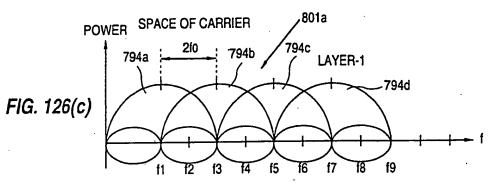
The Court of the C

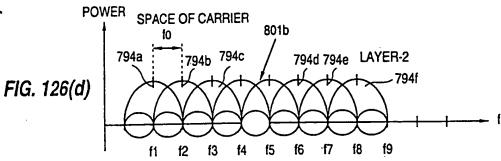












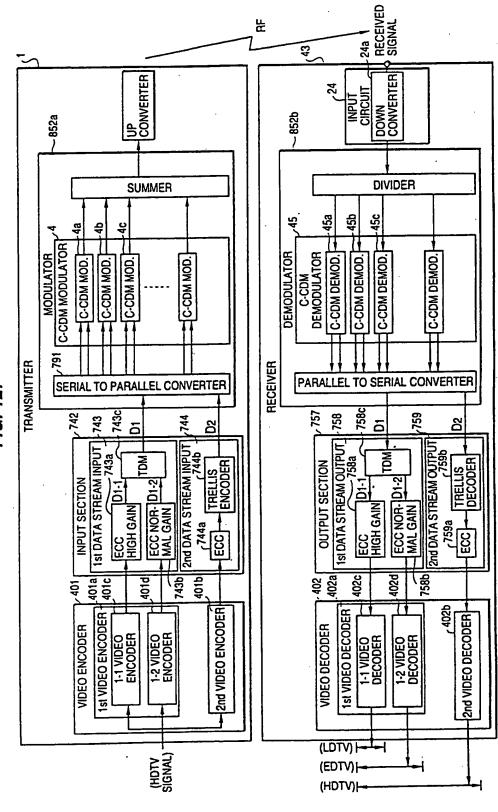


FIG. 128(a)

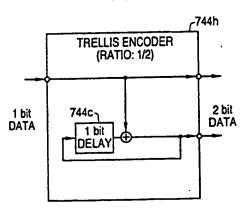


FIG. 128(d)

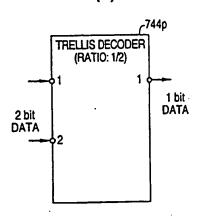


FIG. 128(b)

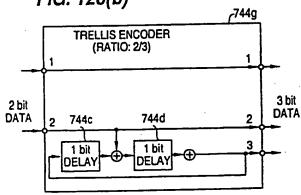


FIG. 128(e)

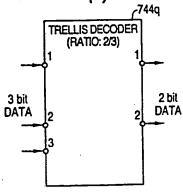


FIG. 128(c)

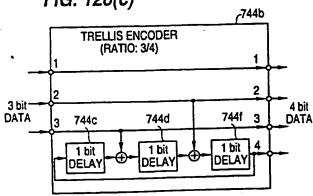
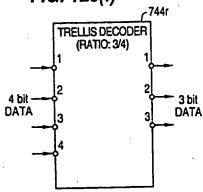
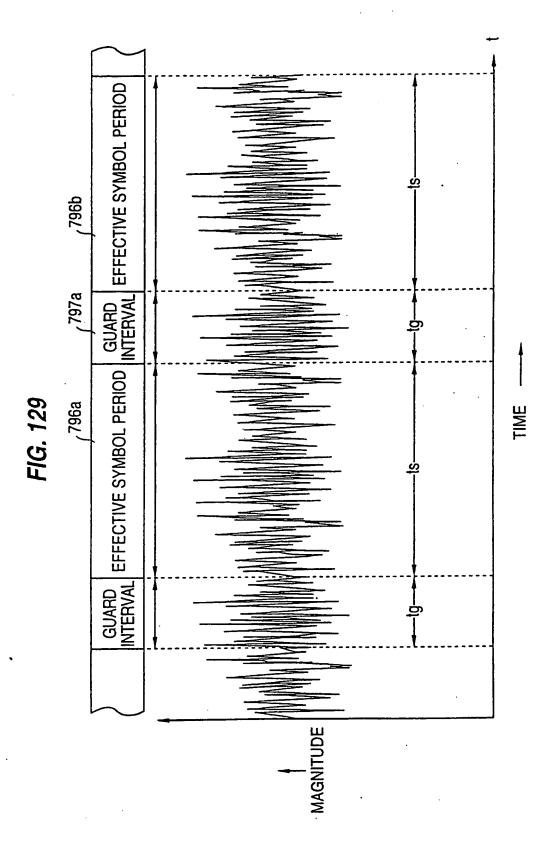
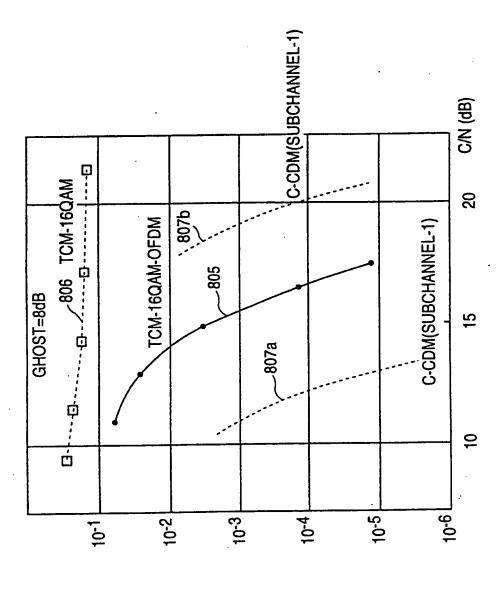


FIG. 128(f)









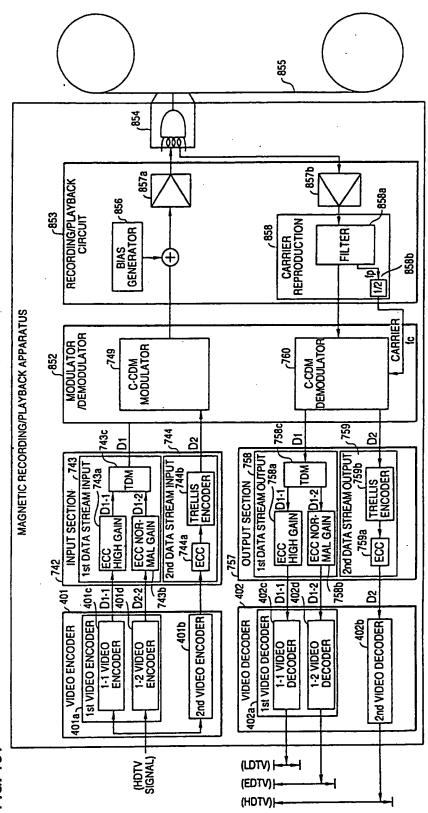
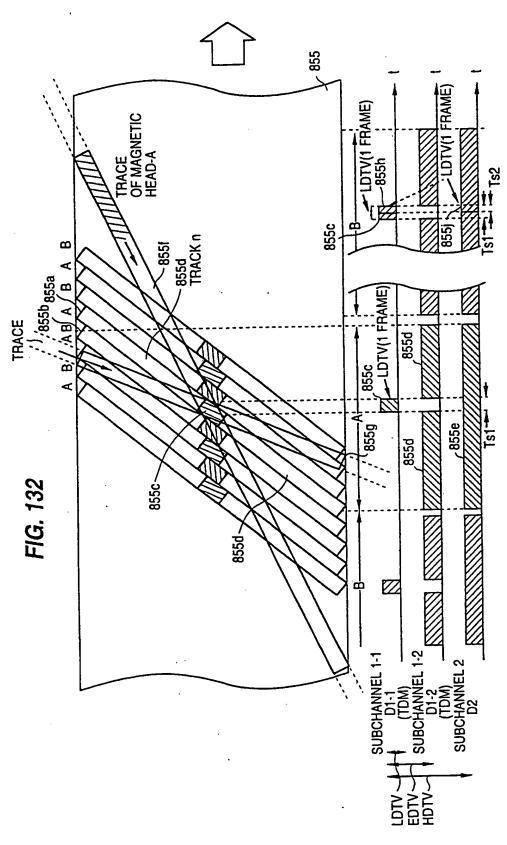


FIG. 131





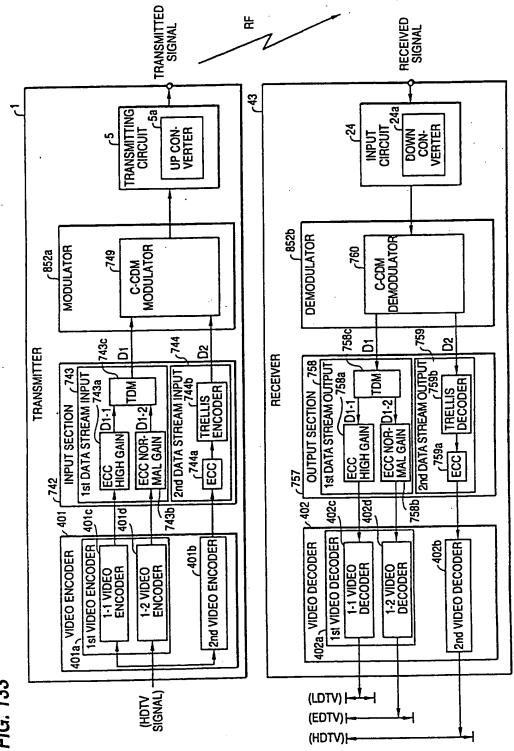
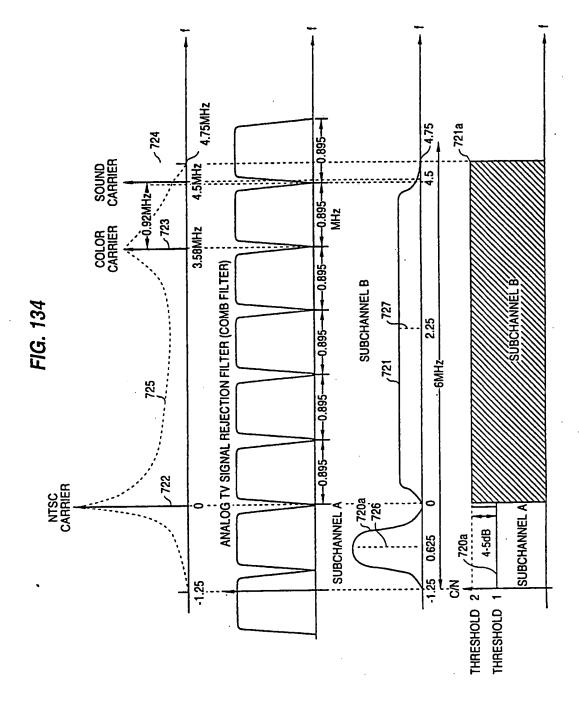
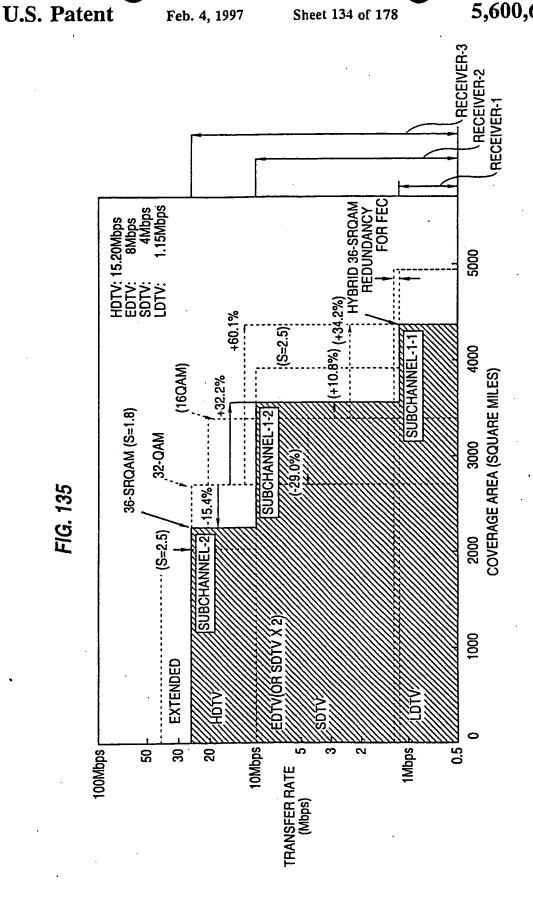
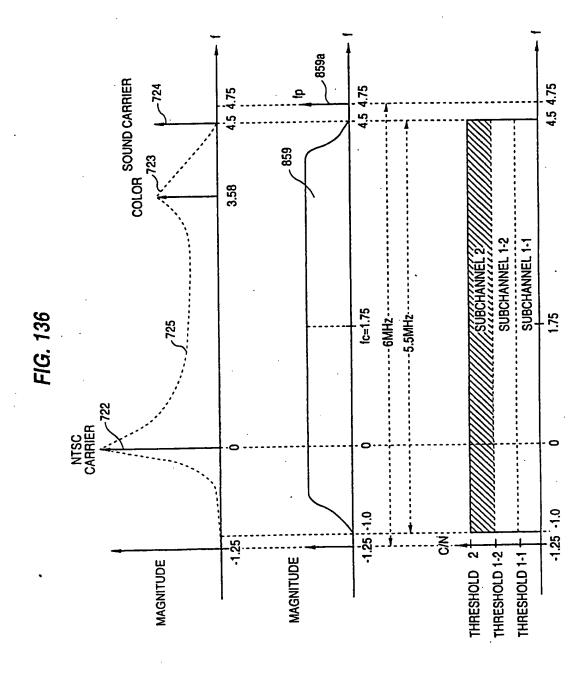


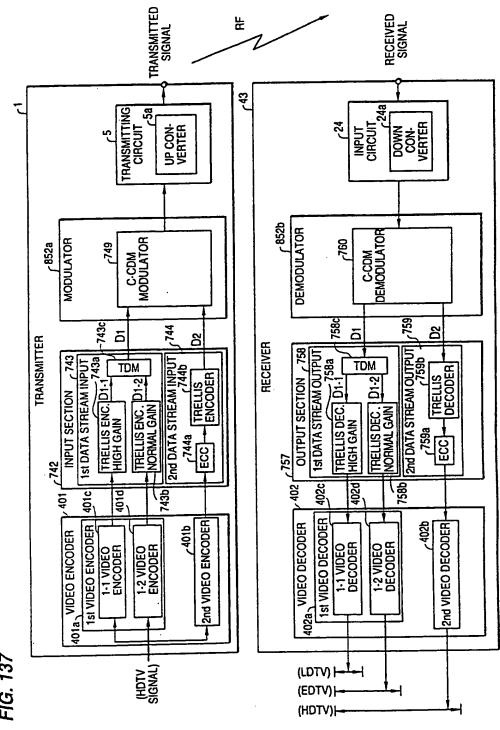
FIG. 133

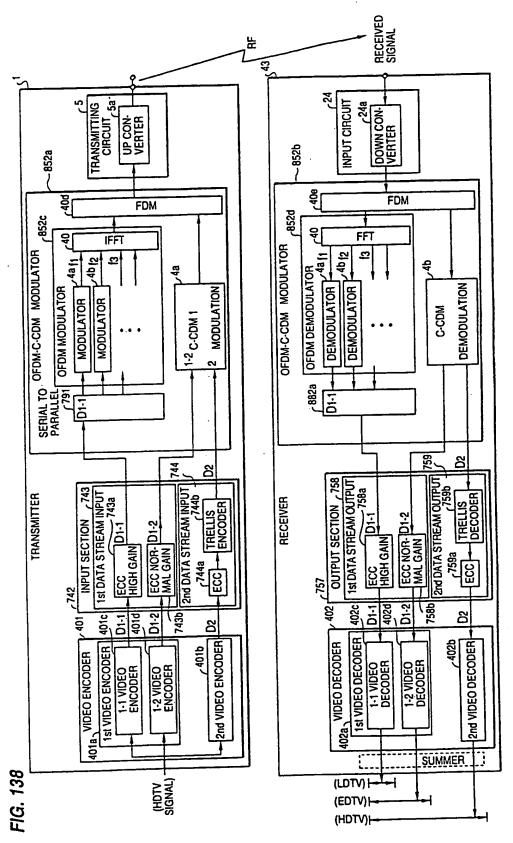






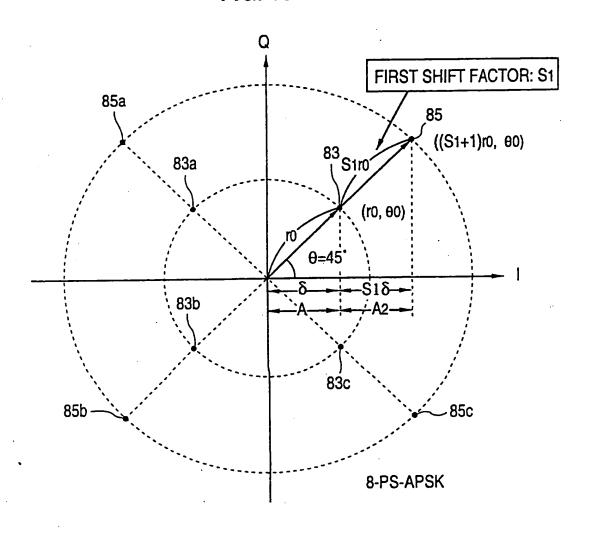






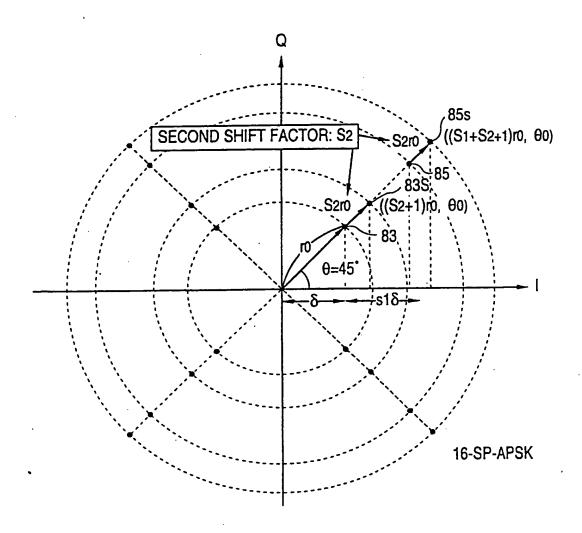
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FIG. 139



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FIG. 140



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FIG. 141

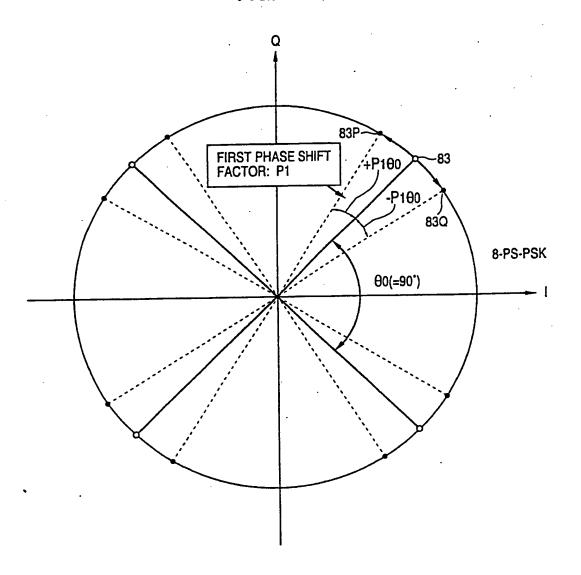
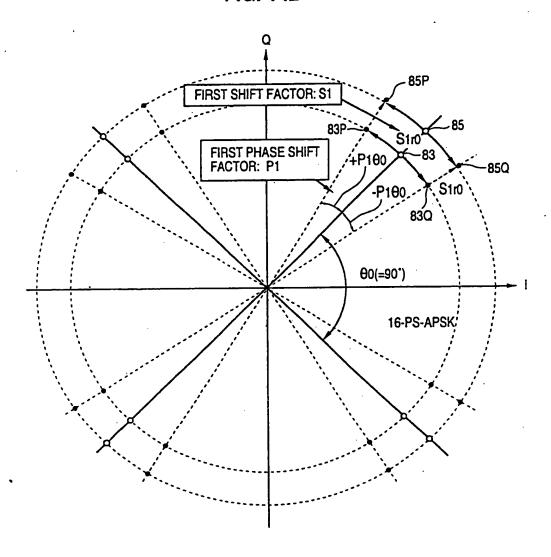
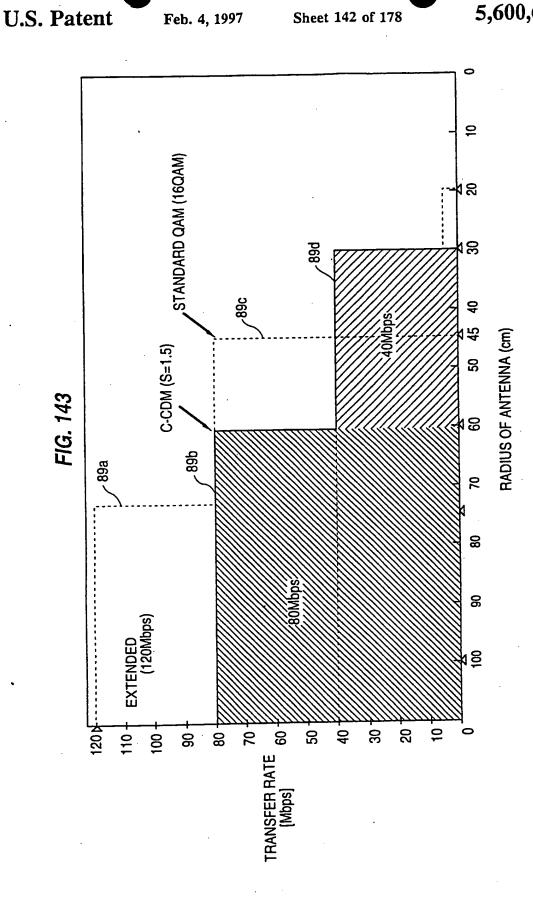


FIG. 142





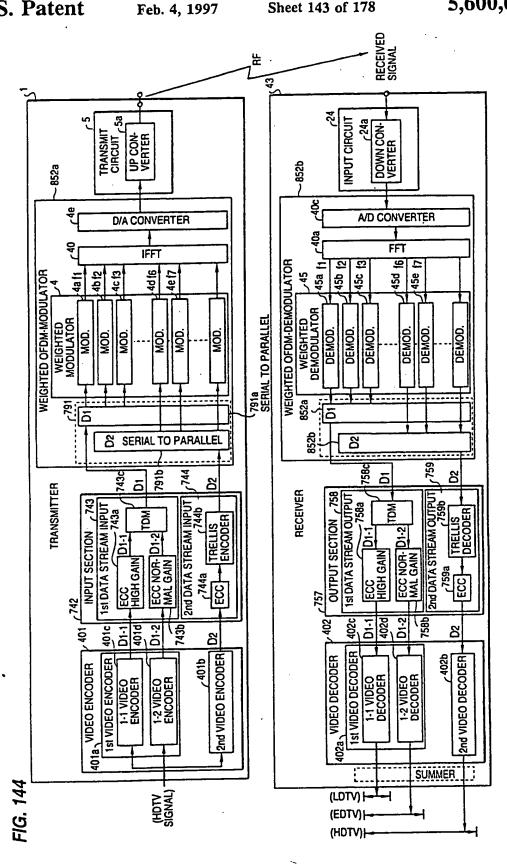


FIG. 145(a)

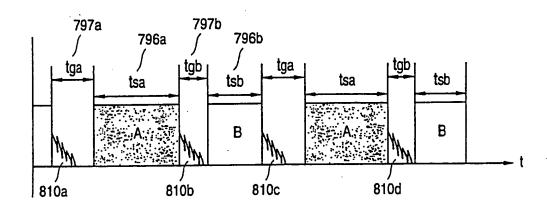
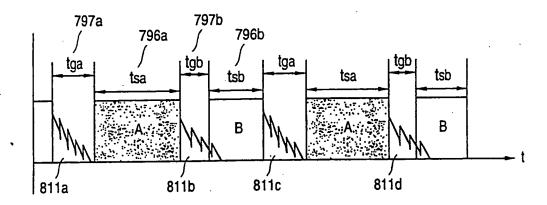
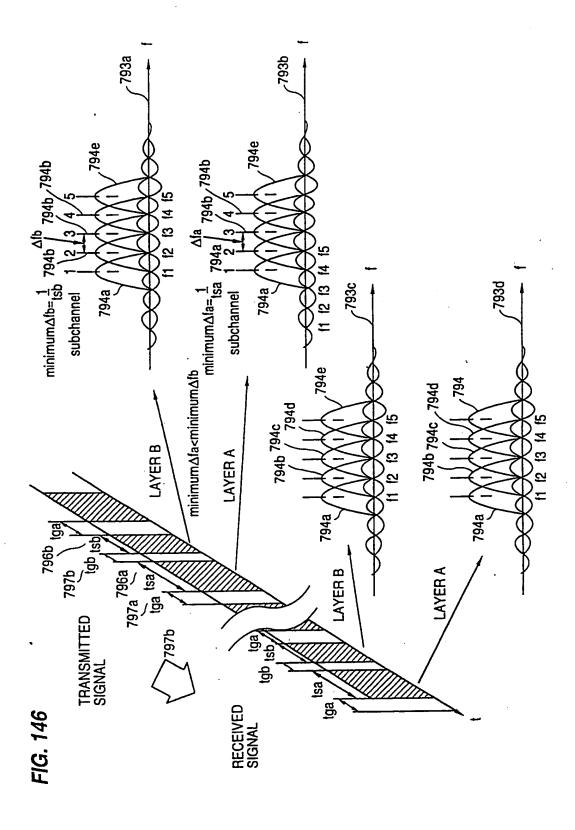
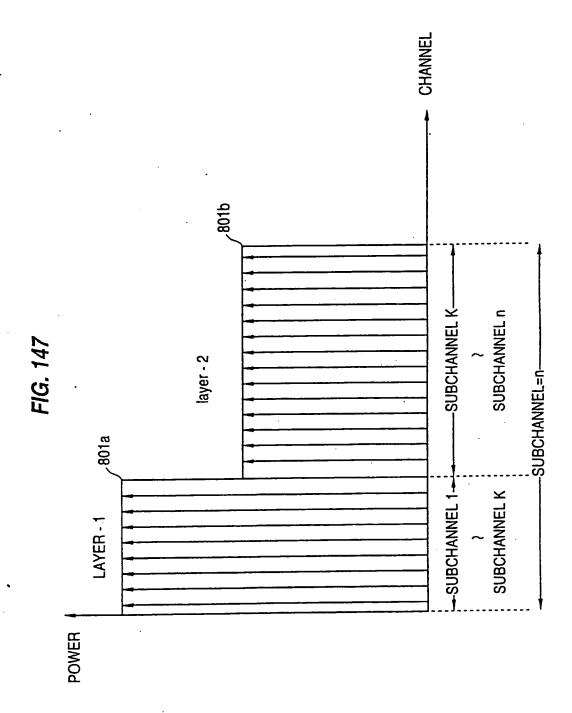
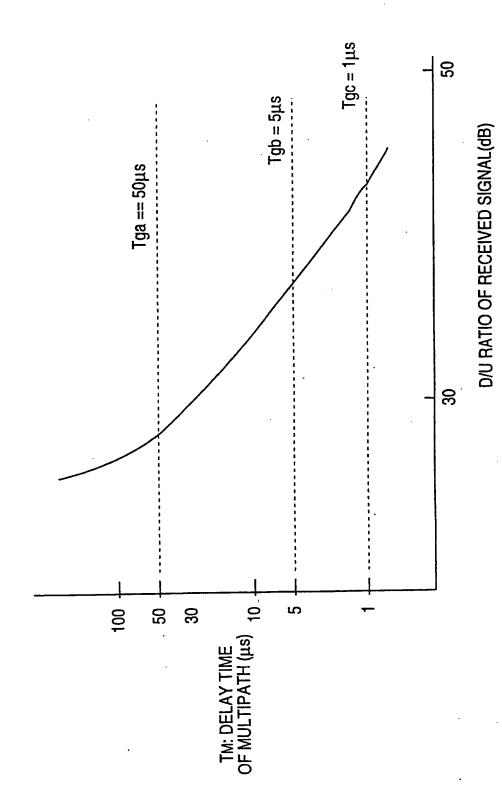


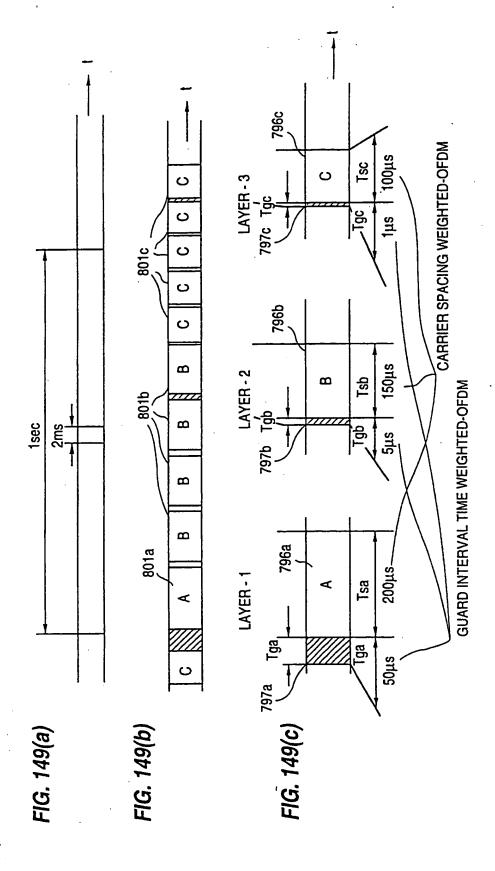
FIG. 145(b)

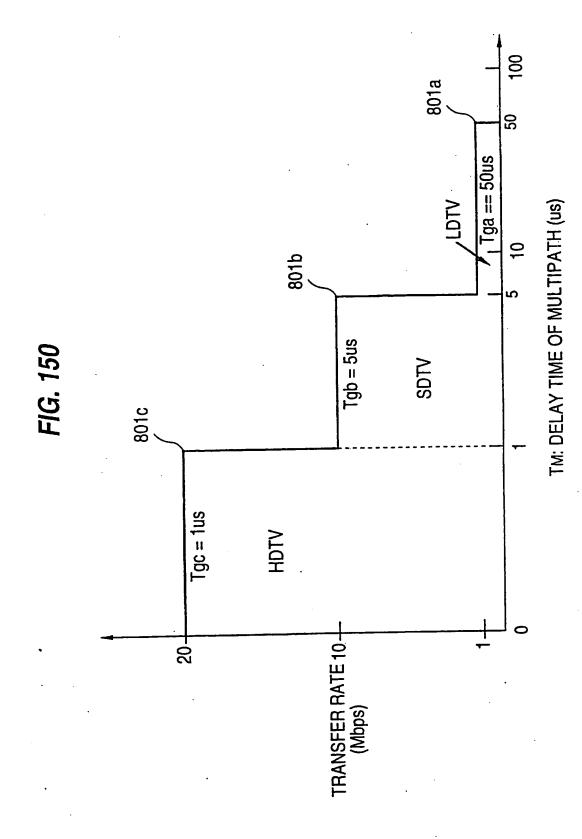




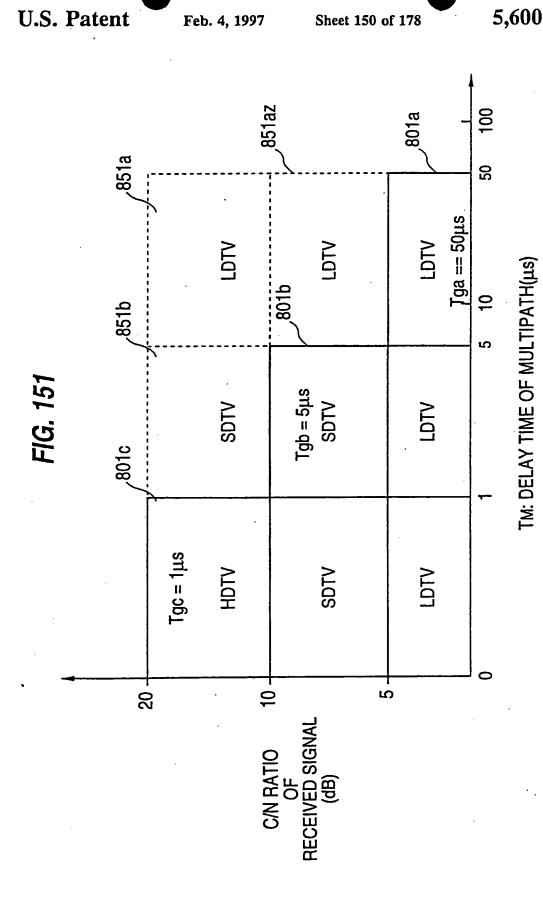


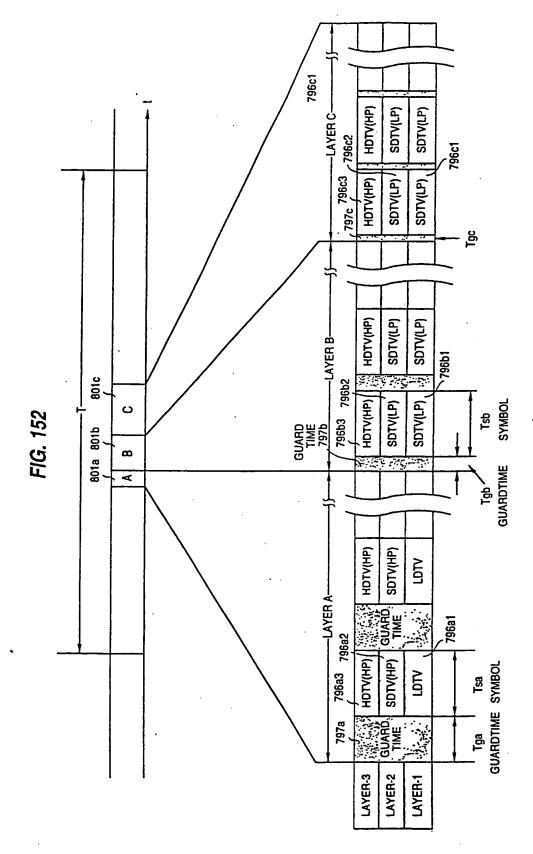




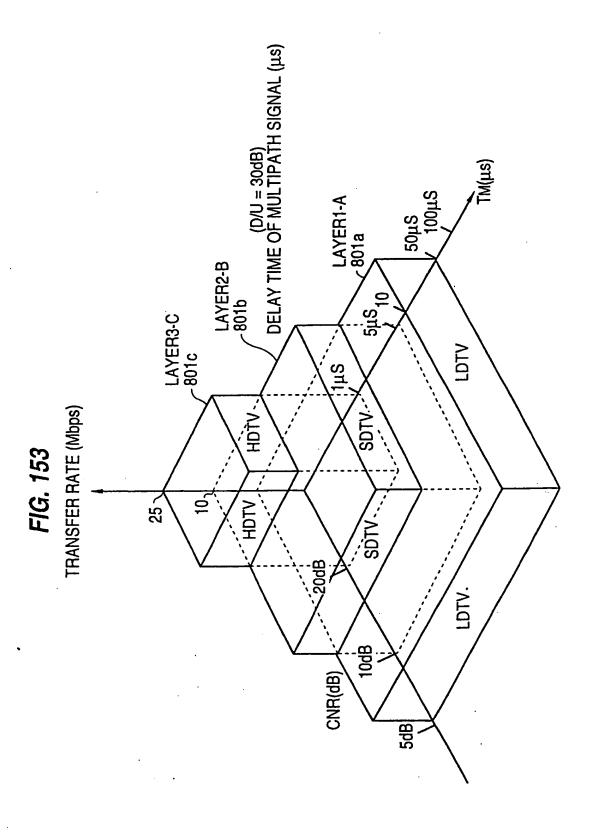


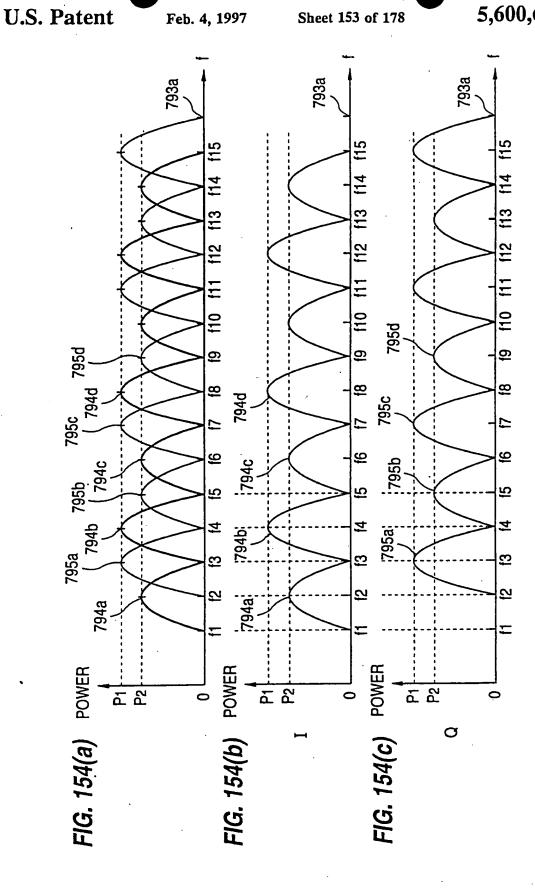


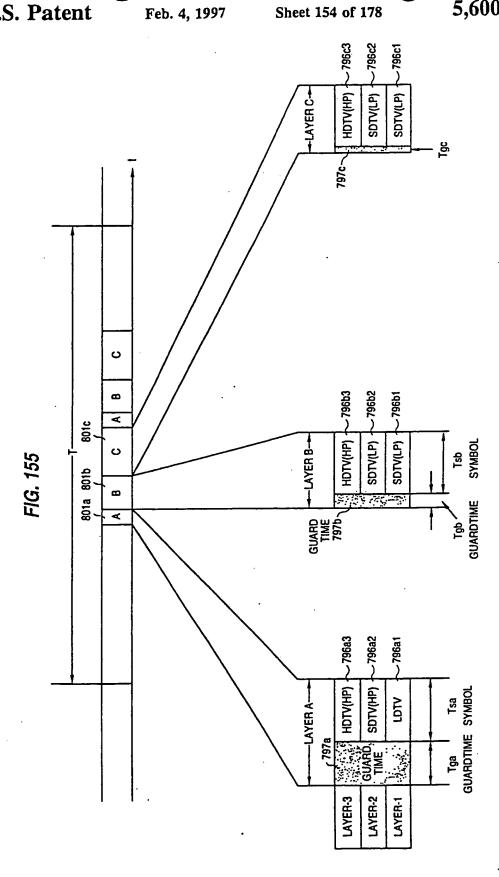












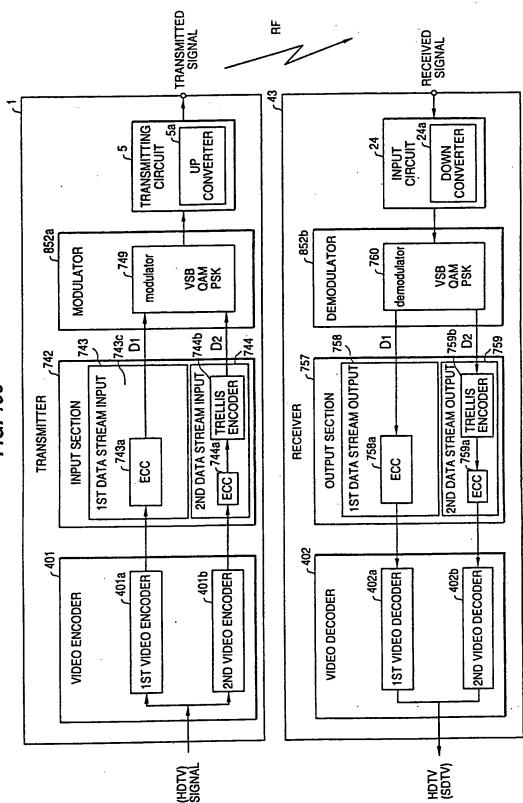
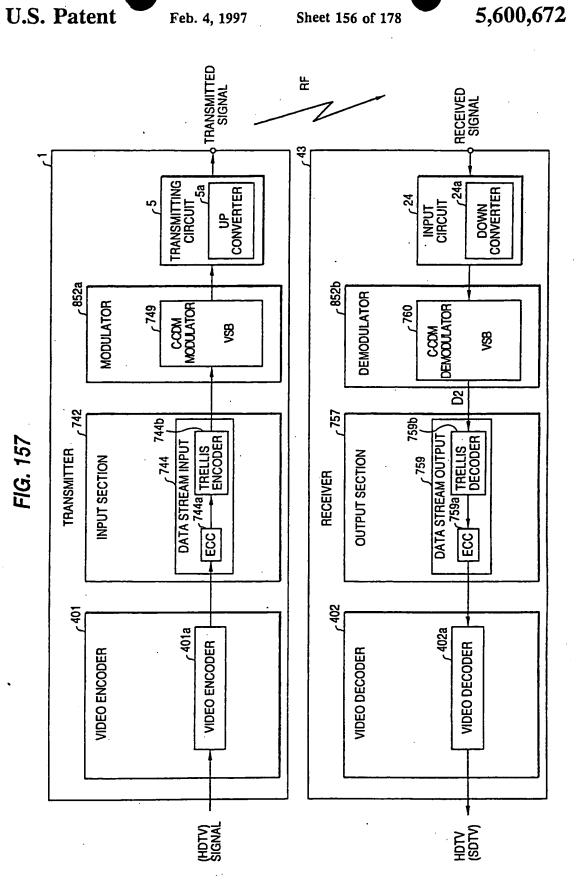
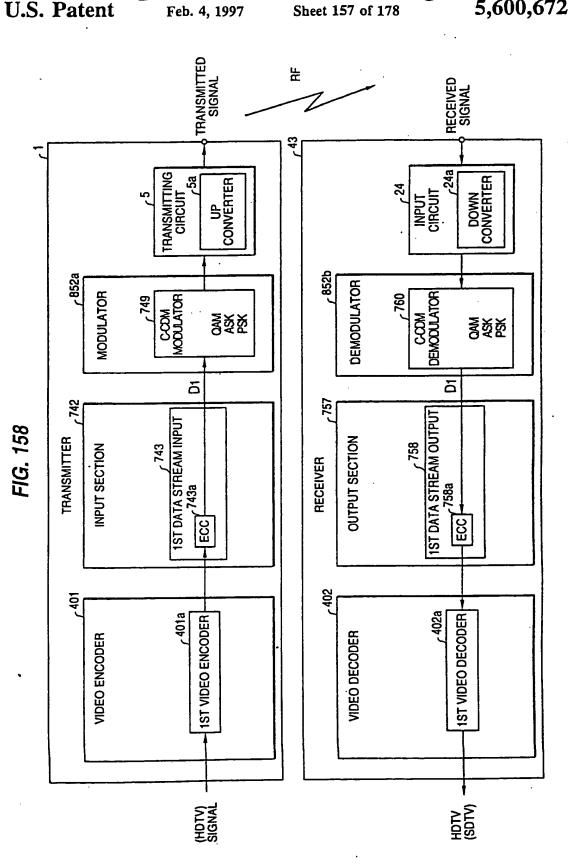
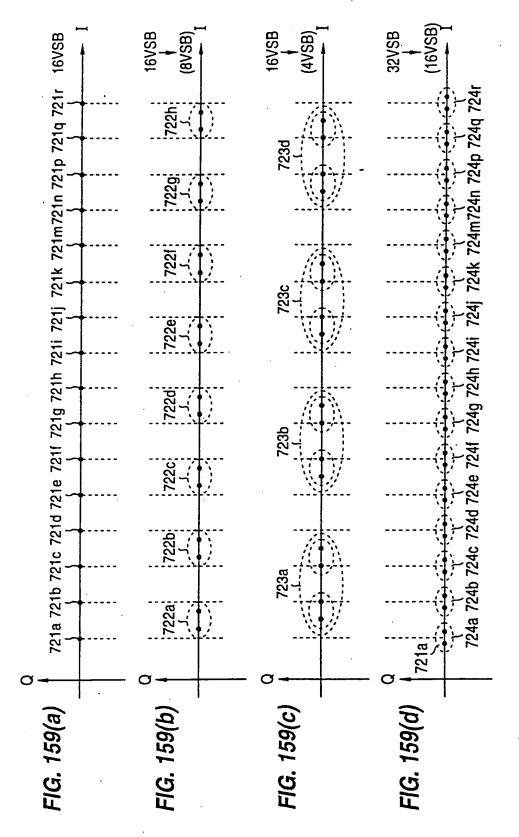


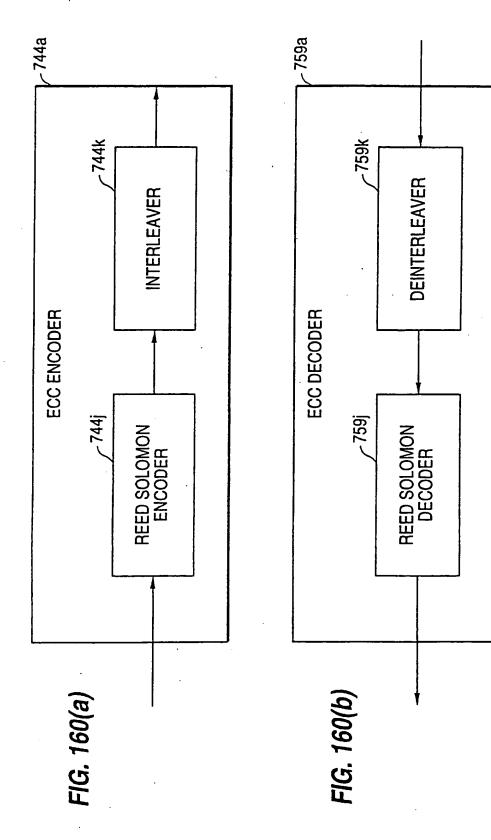
FIG. 156



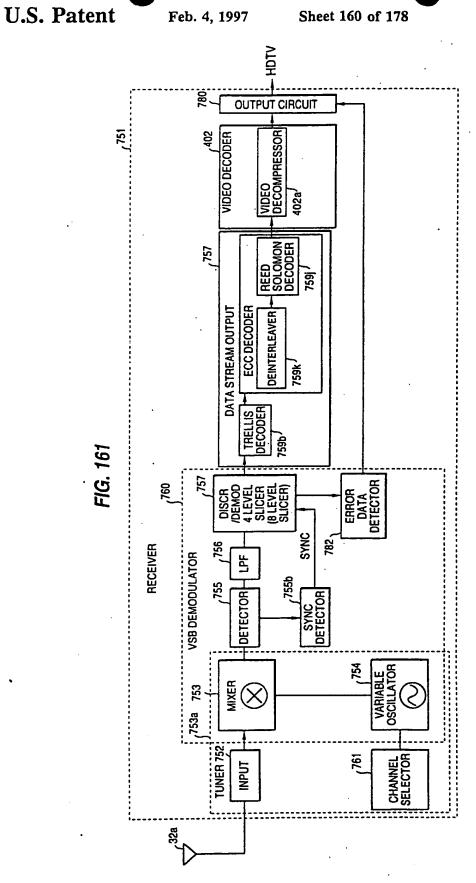


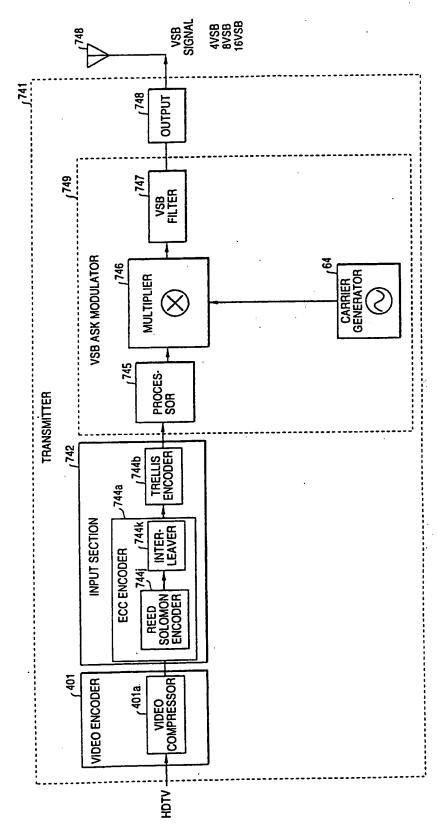


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FIG. 163

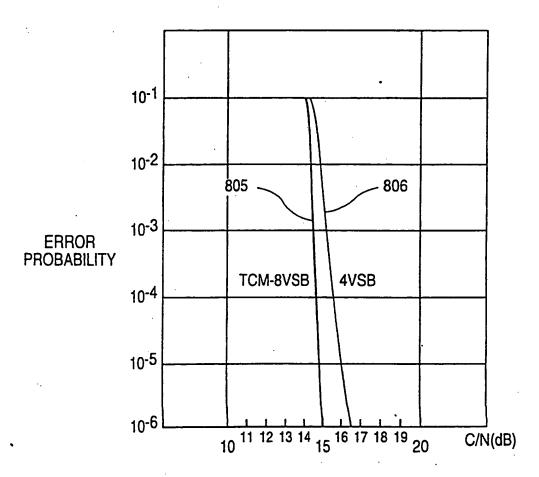




FIG. 164 10-1 4VSB TCM-8VSB 10-2 806 805 10-3 **ERROR PROBABILITY** 805a 805b 10-4 SUBCHANNEL-2 OF TCM-8VSB SUBCHANNEL-1 OF TCM-8VSB 10-5 10-6 10 11 12 13 14 15 16 17 18 19 20 C/N(dB)



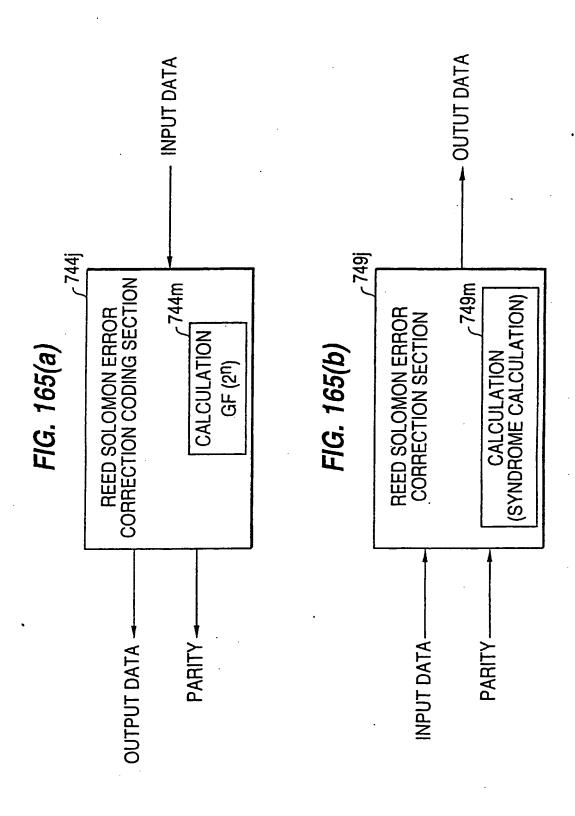
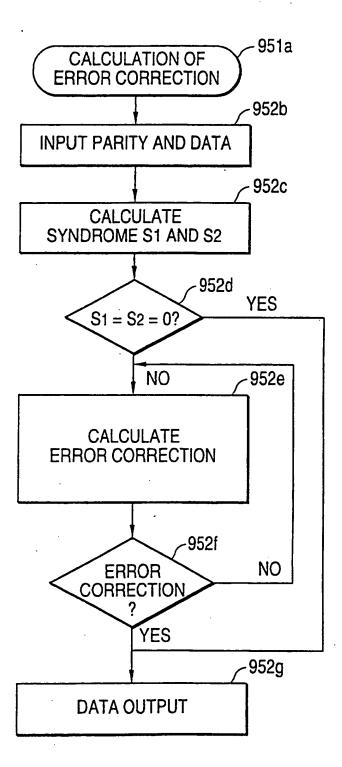
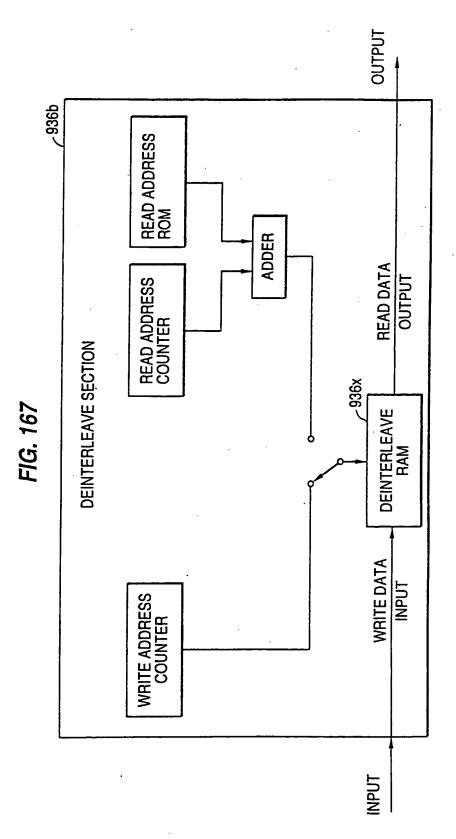


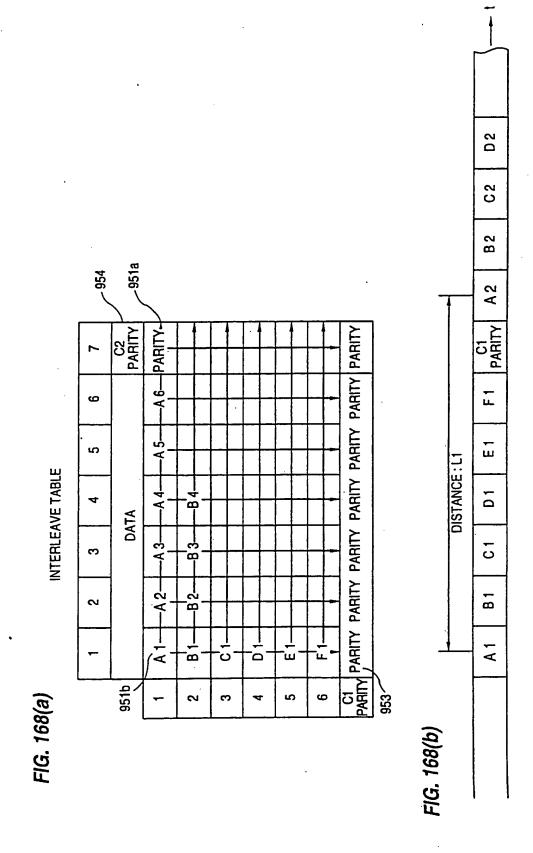
FIG. 166



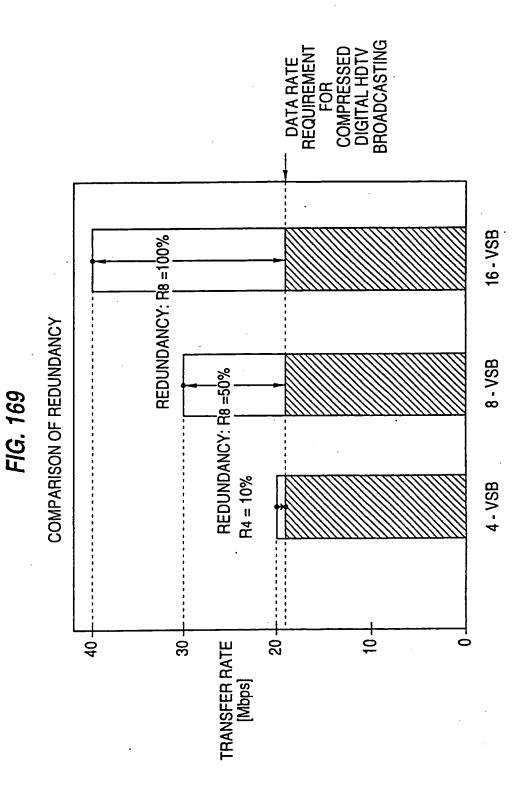
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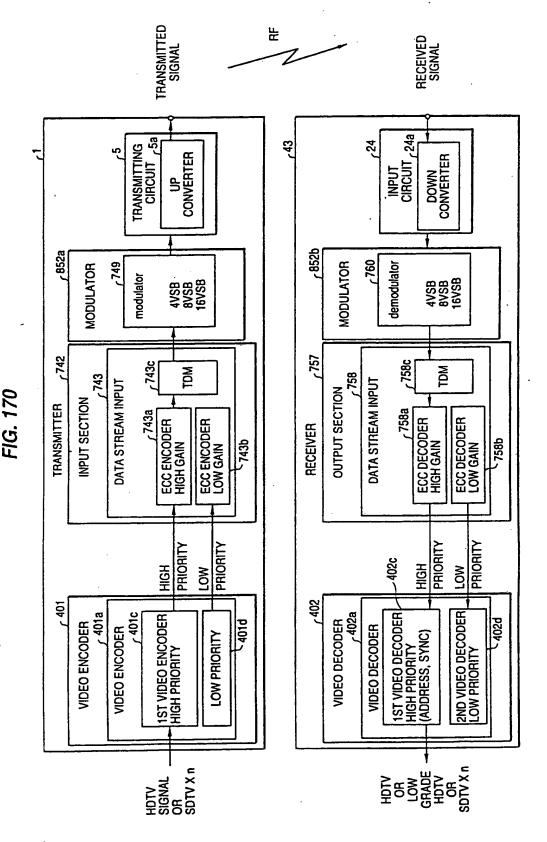


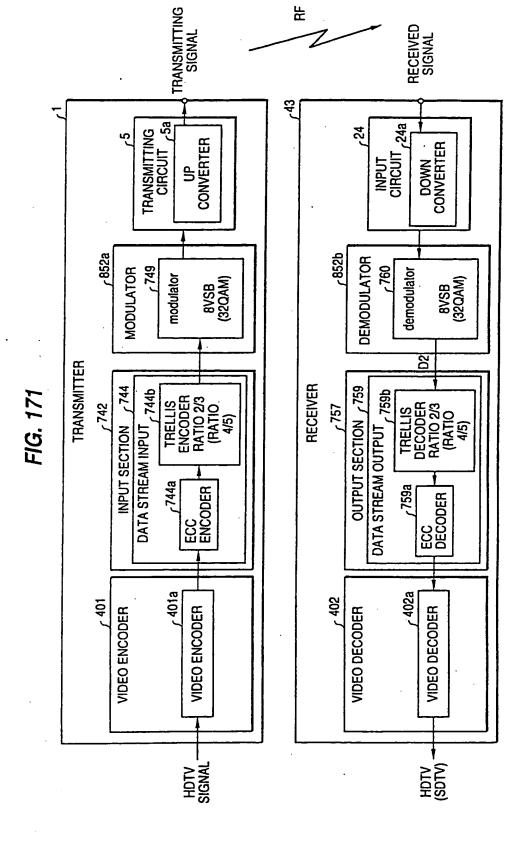




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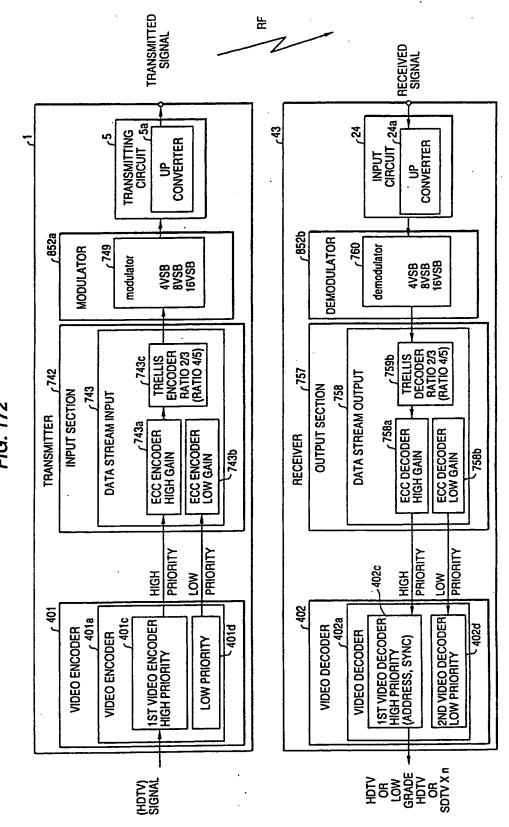
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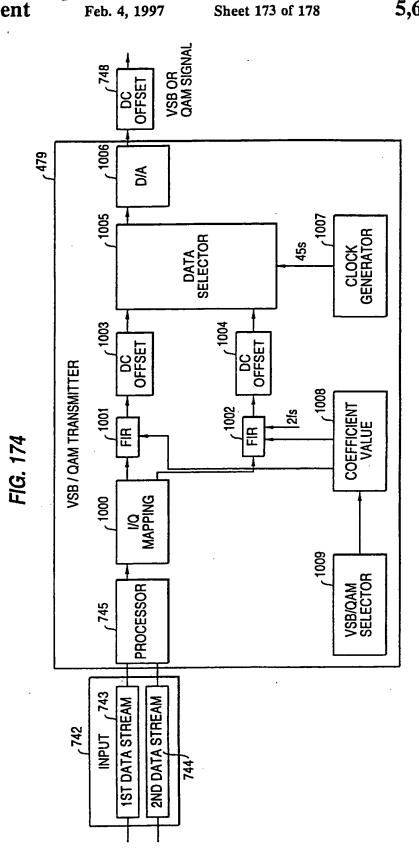
A HILL THE THE THE HILL HAVE BEEN



U.S. Patent 5,600,672 Feb. 4, 1997 Sheet 172 of 178 -855 RECORDING REPRODUCING CIRCUIT 856 BIAS GENERATOR CARRIER REPRODUCING CIRCUIT 858b 858a∼ CARRIER DEMODULATOR C-CDM DEMODULATOR 4 - ASK 8 - ASK 16 - ASK C-CDM MODULATOR 4 - ASK 8 - ASK 16 - ASK RECORDING AND REPRODUCING SYSTEM MODULATOR 760 2 20 5 2759 2nd DATA STREAM OUTPUT 7590 12590 2nd DATA STREAM INPUT OUTPUT SECTION , 758 INPUT SECTION 743 - FECT - ENCODER ISI DATA STREAM OUTPUT 757 TRELLIS INPUT SECTION FCC FCC ည္သ ည္သ 1st VIDEO ENCODER 401b 2nd VIDEO ENCODER 1st VIDEO DECODER 2nd VIDEO DECODER 401a 402a VIDEO ENCODER VIDEO DECODER

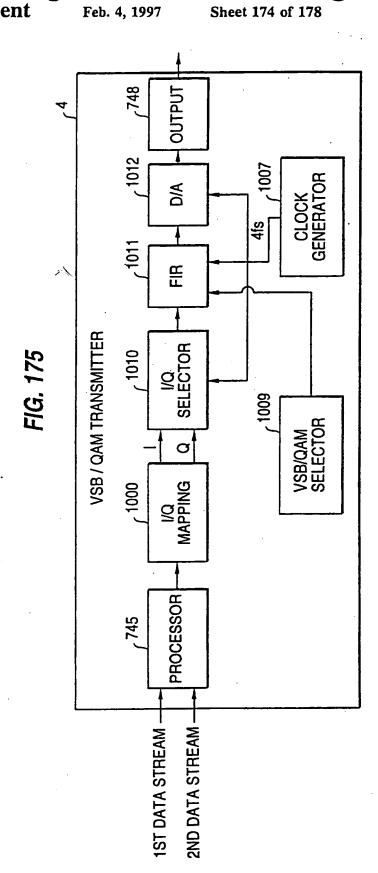
> (HDTV) SIGNAL

FIG. 17

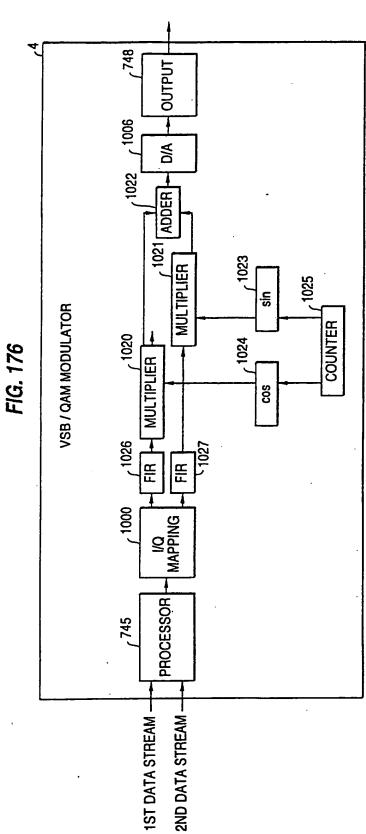


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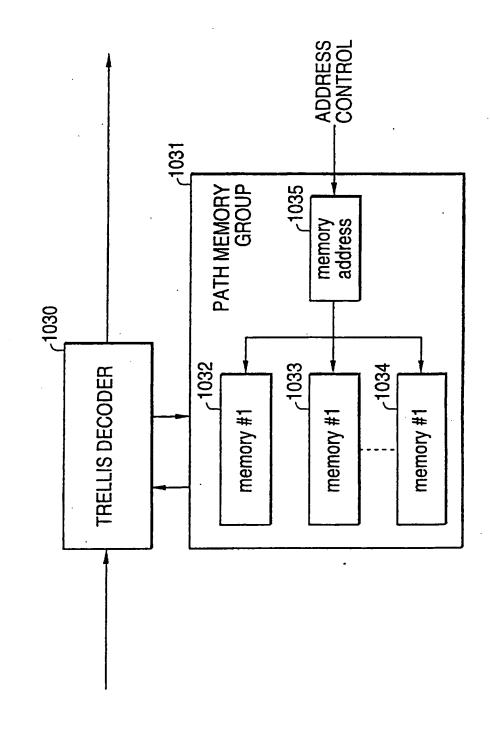


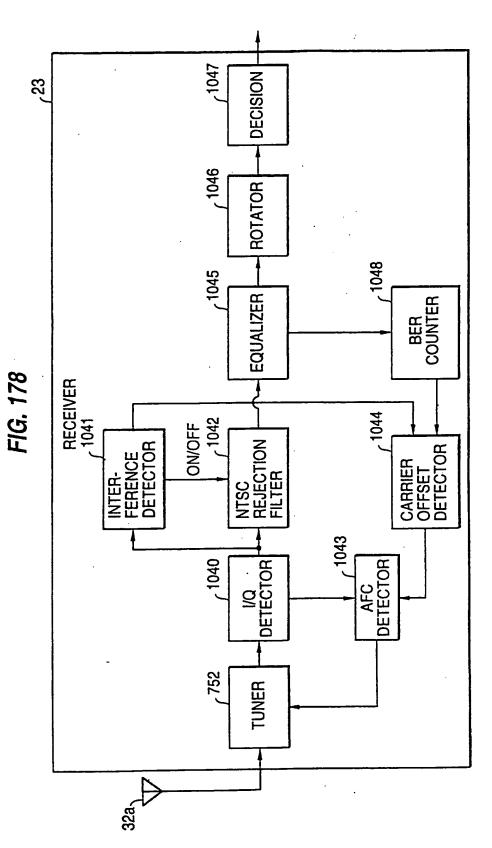


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